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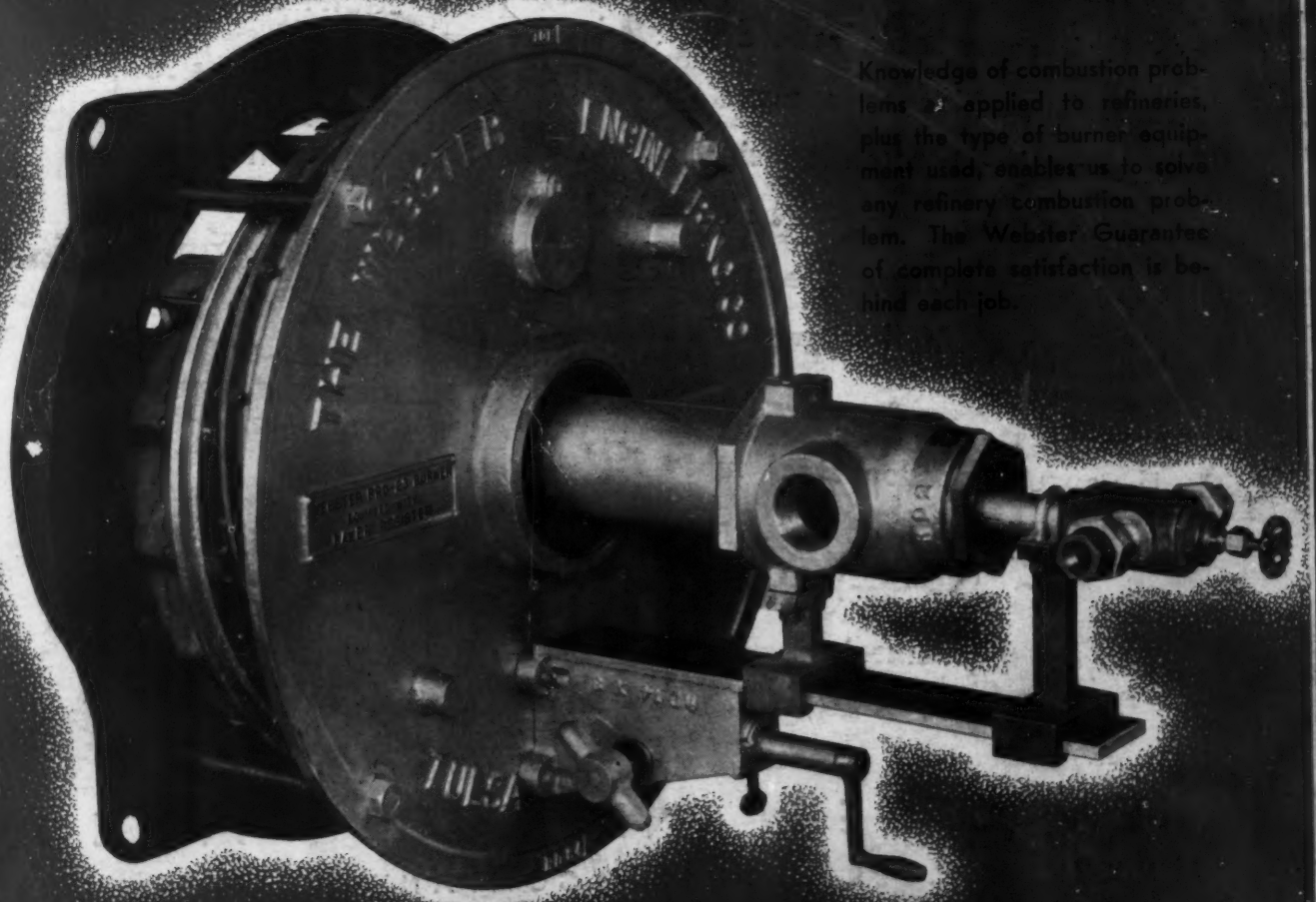

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VOLUME 16, No. 1 JANUARY, 1937

REFINER
AND NATURAL GASOLINE MANUFACTURER

A Gulf Publishing Company Publication

The Look Box

Outlook

WITH the first issue of the new year, The Refiner presents a comprehensive analysis of the economic and technical trends and developments during 1936 and a look into 1937. This data is presented for the purpose of correlating all latest available technical and economic data and interpreting it for the guidance of readers. Progress demands study, constant effort to keep abreast of continued development, and the petroleum refining industry is indeed most rapid and active in its progress.

The petroleum industry enters the new year in good shape. Figures available covering 1936 show that the year brought a new all-time record production and consumption of petroleum and its products. Slight losses of markets during the depression were recovered and the industry is now in new high ground as regards the demand for its products. Not only gasoline and lubricating oil, but kerosene, fuel oils and other products have recovered remarkably in demand. Also, supply has been well balanced with the demand, the successful production control bringing, in fact, steady withdrawals from storage. Above-ground stocks of oil have been reduced to sound economic levels.

Because of the successful restriction of production and the prevailing comparatively light inventories, the oil industry has achieved improved prices, and prospects of still better prices. With the volume of business at all-time record levels, and with the prices favorable, satisfactory earnings naturally occurred. Since there have not been so far any material changes in the conditions surrounding the industry, continued favorable earnings in 1937 are indicated.

This is all reflected back directly to petroleum refining construction activity. While in the following pages of development and progress review and forecast discussion an important list of modernization programs is presented, covering both domestic work and activities abroad, there is not included details on projects and planned expansion and modernization work which will make 1937 an even more active year in construction than was 1936—the best in five years.

The prevailing favorable conditions have shown management that the time is ripe for the investment of capital in new equipment, processes and materials. The industry is now willing, financially, to take advantage of the results of research and development which have provided achievements in engineering and technology to the end that the modern processing tools are far better in efficiency than was dreamed of a decade ago. Petroleum refining, now becoming truly a chemical engineering industry, is well on the way to scientific achievements in many and differing fields of endeavor. The results of such progressiveness is not only to take the industry into the manufacture of larger recoveries of better primary products, but is to widen still further the types and varieties of products which the industry will market, all of which must contribute to the profits derived from manufacture.

Developments

In Petroleum Manufacturing

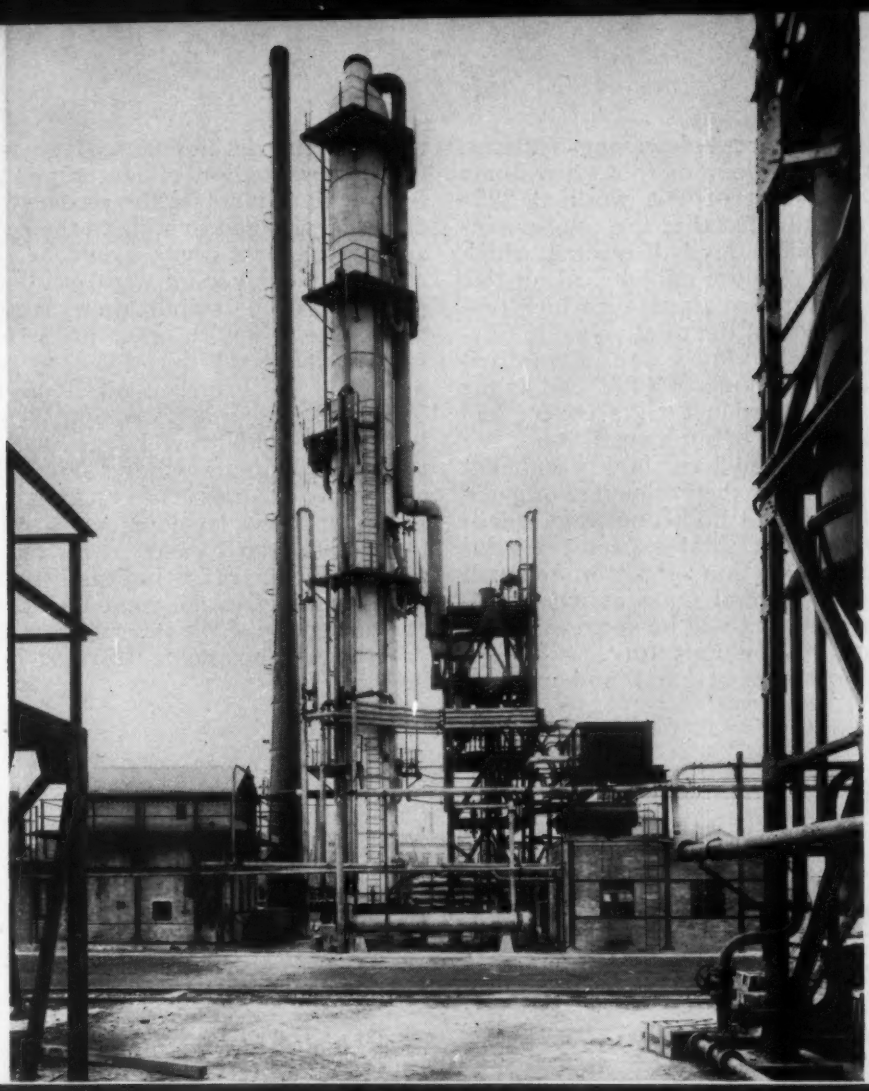
THE general trend in petroleum refining practice and technology, now well established, is definitely toward the utilization of new and highly scientific chemical engineering processes. The use of heat and pressure during the past score of years has accomplished much and has given the industry the variety of engineering achievements now generally termed cracking practice. Such processes as hydrogenation, the use of aluminum chloride, and polymerization in commercial practice have opened up the vast field of catalysis. Through the employment of heat, pressure, and catalysts, a wide variety of processes will become available bringing to the industry tools with which to achieve results of even greater economic and scientific importance. Given such tools the refining industry can "shuffle" its hydrocarbons and selectively group them to suit the best needs of its various requirements.

Progress is taking the industry into a stage where its motor fuels can be economically tailor-made chemically as well as physically, and where its lubricants will be likewise chemically as well as physically best suited for various lubricating jobs. Processes for synthesis of what is needed, for separation of one type of hydrocarbon from another, for decomposing and recombination, for rearrangement of molecular structure of any type of hydrocarbon, and facilities for precise fractionation, commercial in application, processes in fact, with which to accomplish practically any presently known requirement are now available. And this does not include the processes available for production of chemicals, solvents, resins, sulpholenes, alcohols, acids, rubber substitutes, and a host of other products. This progress is just beginning to be felt within the industry. The future is to bring achievements in technologic development and chemical engineering in petroleum manufacturing plants now very difficult of appraisal.

Four years ago, February 1932, THE REFINER presented the first of its Process Handbooks. In October of 1936 a development issue presented 28 commercially employed processes not in use in 1932. In addition another dozen important processes were in the semi-commercial stage and close upon announcement, and at this writing 10 additional important processes are nearing final development stage. Perhaps there are more, but in all, the year 1937 will probably see the commercial application of over 50 new processes affecting operation of practically every department of the refinery, which were not "in the cards" in the early part of 1932. Such progress in four years is certainly indicative of what is to come.

Dr. V. N. Ipatieff of Universal Oil Products Company, a recognized authority on matters technical pertaining to oil, definitely places the industry as now entering the "catalytic period" (see REFINER, Vol. 15, No. 11, November 1936, page 481). Such catalytic practices as now are available, according to this authority, include polymerization, selective polymerization, depolymerization, hydrogenation, dehydrogenation, cleavage, hydro-polymerization, depoly-alkylation, destructive alkylation, alkylation, isomerization, and cyclization. Obviously, under such conditions chemistry, chemical engineering, engineering and technology are to be increasingly important. A casual review of the literature of petroleum during recent years, a like review of distribution of patents by various companies, and knowledge of work underway in many research laboratories, as well as the work of such men as Ipatieff and others throughout the world, definitely points to the conclusion that petroleum refining is entering a new phase of its technical history and achievement.

Application of new scientific processes to the manu-



Courtesy
FOSTER-WHEELER CORPORATION

facture of petroleum products and by-products, has brought about a condition where it is becoming increasingly difficult to find technically trained staffs for the proper development of such process as well as for the proper operation and supervision of the units. With larger use of solvent extraction and dewaxing and deasphalting, with larger use of selective cracking, reforming, and other cracking adaptations, and with increasing use of polymerization, it has become not only difficult to find properly trained operators and supervisors, but the technical minds so essential to efficiency in operation and development work are scarce.

Research and development work which lies ahead of the industry is of such nature that if profitable application of scientific knowledge is to be appropriated by the industry more highly trained men will be required and in greater numbers. Here is a condition which prompted Dr. Hugh S. Taylor of Princeton University to state before the American Petroleum Institute in November 1936, "the problems ahead of the oil industry are more complex and more severe than those that the industry has so successfully met hitherto. It would, therefore, seem necessary that, to meet the new demands, a higher type of scientific achievement will be demanded by the industry's research personnel. I cannot see that this can be accomplished within the frame-work of the present Ph.D. requirements in the universities. I believe it will be necessary for the industry to finance, in increasing measure, fundamental research at the post-doctorate level. I believe that the yield of such a subsidy will be worth the expense which it will involve."

EQUIPMENT BECOMES OBSOLETE

The rapidity of technical progress and development as briefly outlined in the foregoing discussion brings into the spotlight the important factor of obsolescence. The rate of improvement in petroleum refining technique, in its processes and in its many major items of equipment, has been so rapid that no other industry has such a high rate of obsolescence. Cracking and distillation have been affected largely by such progress and the new type of combination facilities with their low operating costs especially at high capacities, renders the older type of widely used individual cracking unit and topping units obsolete both from the standpoint of per-barrel costs and flexibility. Along with major equipment continually heading toward obsolescence and periodic replacement, another factor which tends to make refining a more expensive operation is corrosion. It is estimated that the annual bill for corrosion effects in the industry is $125,000,000. Thus corrosion becomes a major factor in the annual construction activities, replacements and modernization. Corrosion of equipment probably accounts for the expenditure of half of the estimated 2 cents to 4 cents per barrel maintenance and repair bills.

During the past few years since solvent extraction and solvent dewaxing processes have come into vogue, the refining industry has erected 32 solvent

extraction units and 22 solvent dewaxing systems, giving a total of 54 installations of this type. Some estimates place the total cost of this work at $25,000,000. Further, it is estimated that the total potential capacity is but approximately half erected, which involves the expenditure of more millions. All of this work has been done to improve a product which represents but a small fraction of the total valuable fractions of the crude charged to stills, and in comparison to the importance of gasoline as a fuel and as the industry's principle money product, the recovery and marketing of lubricating oils is but a small item.

Thus with processes of modern, highly efficient and scientific type at hand for the production of gasoline of higher anti-knock and higher mileage qualities, it becomes certain that total expenditures for new facilities for the production of motor fuel will mean the expenditure of several times as many millions annually as has been and will be spent for modernization of lubricating oil manufacture.

All of the newer processes at hand, and most of those in the development stage which are designed for the production of larger yields of better motor fuels tend to increase the recovery of such fuels from crude oil charged to stills to the point where it would appear that less crude would be required by the industry for conversion into gasoline. With cracking, polymerization, stabilization, recovery, and similar processes, and with other processes yet to come, in each instance the purpose is to recover more gasoline from the barrel of oil. Thus total yield for the United States is approaching 50 percent. No doubt this figure will grow larger as conditions improve, technique is improved and skimming plants now operating as such turn to cracking.

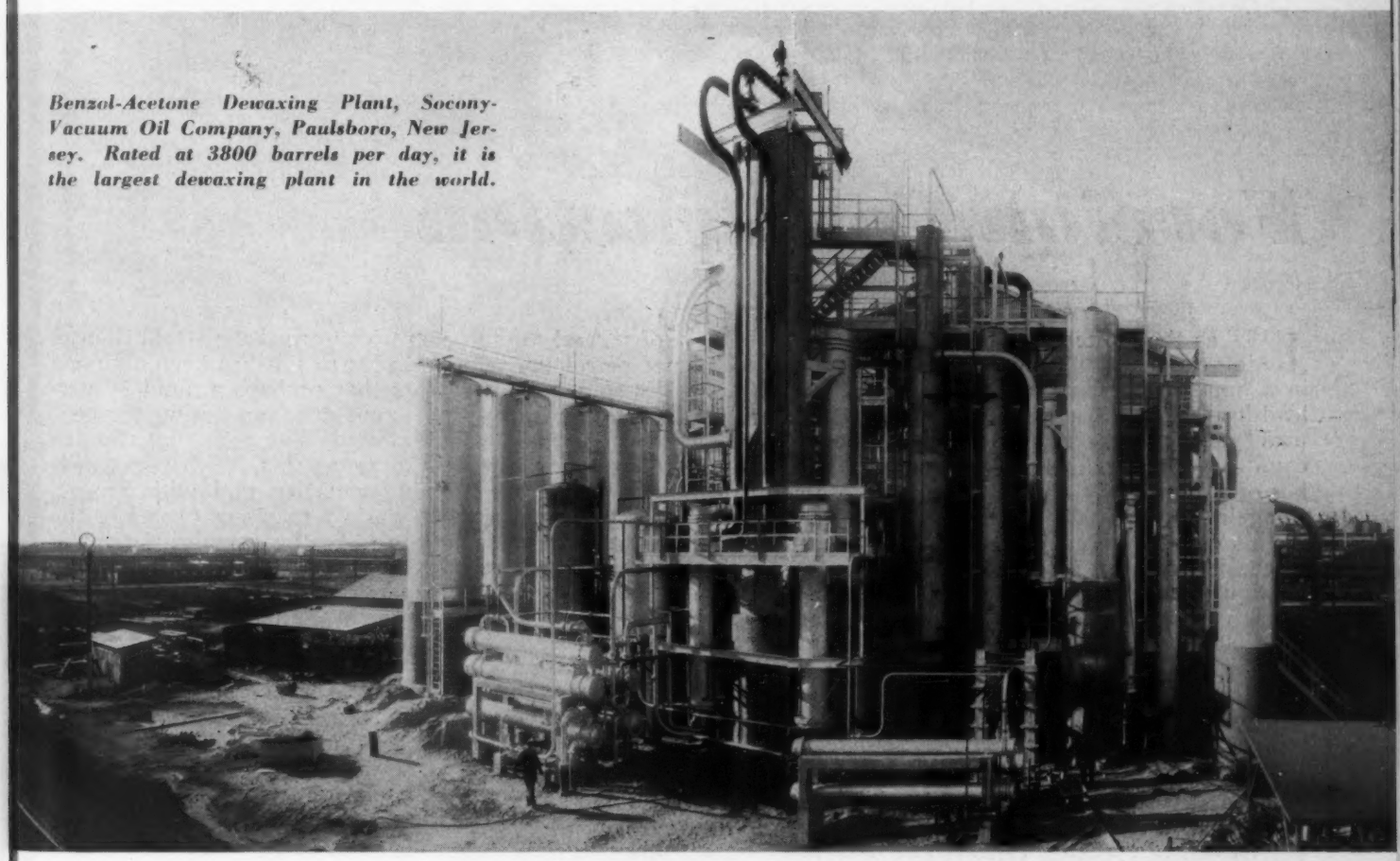
While every development in refining is definitely toward increased yield, so far as motor fuel is concerned, the decrease indicated in demand for crude by refineries does not come about because of the ever increasing use of the internal combustion engine with subsequent demand for further quantities of motor fuels.

Domestic Construction

A LARGE part of the domestic refinery construction work begun last year falls into the classification of major programs. Few of these programs were completed in 1936 and by far the majority of them will see completion this summer. Several modernization programs of the major type range in cost from $3,000,000 to $5,000,000 each and it is expected that the year 1937 will witness announcement and partial completion of several new major installations. These will include new combination cracking plants, new polymerization installations and new solvent refining and dewaxing plants for the most part. The work at present under way at Pan American Refining Corporation's Texas City, Texas, plant which includes a new 30,000-barrel combination unit and a large polymerization plant and which doubles capacity of this relatively new refinery is typical of present major programs. Shell Petroleum Corporation at its Houston plant is now engaged in a major construction program involving new distillation, cracking and reforming facilities, new steam generating equipment, wharfage and tankage—all of which will bring total capacity of this refinery to 76,000 barrels per day. Shell Oil Company of California at its Martinez and Dominguez, California, refineries is now engaged in a major construction program involving modernization of distillation and cracking facilities, which, it is reported, may run into several millions before completion. Atlantic Refining Company, at Atreco, near Port Arthur, is building a 20,000-barrel combination type refinery to be equipped with polymerization unit and all of the usual accessory systems which will cost over $3,000,000. Humble Oil & Refining Company at Baytown is carrying out plans for construction of a large polymerization plant and a new combination cracking unit, and has recently completed a new Edeleanu solvent plant working on naphthas. The latter is the first commercial installation of its type. The Pure Oil Company now has underway at Nederland, Texas, a 20,000-barrel combination unit, at Toledo, Ohio, an 8,000-barrel combination unit, and at Cabin Creek, West Virginia, a 1,500-barrel cracking unit and a 2,000-barrel distillation unit. The Texas Company, Gulf Oil Corporation and Magnolia Petroleum Company operating in the Beaumont-Port Arthur, Texas, district have but recently completed installing cracking units, new distillation facilities, solvent refining and dewaxing units, and the first mentioned completed in late 1936 a large polymerization at Wood River, Illinois, during recent months completed a 30,000-barrel combination unit, a 2,000-barrel solvent refining unit and a 2,000-barrel solvent dewaxing plant. The foregoing are typical of the major construction programs figuring in construction news during recent months. Such programs involve the expenditure of millions of dollars, and the several mentioned do not nearly complete the very evident needs of the industry for new and modern highly efficient processing facilities. The industry, it is believed, just got started in 1936, is off, probably, to a good start in 1937 and will go racing into 1938 with a lot of incomplete work underway and with new programs coming into view all of the time.

Among other somewhat smaller activities now underway is the 4,000-barrel skimming and cracking type refinery being erected by Dixie Refining Corporation at Trenton, Michigan. Chalmette Petroleum Corporation at New Orleans has started construction on a new 9,000-barrel cracking plant and is converting its older cracking facilities to topping plant work. Shamrock Oil & Gas Company in Moore County, Texas Panhandle, is erecting a new cracking unit

and a polymerization installation. Petrol Coastal Refining Company, Corpus Christi, Texas, is building a 6,000-barrel combination type refinery. Standard Oil Company of Ohio, at its Toledo plant now has under construction a new 12,000-barrel combination type cracking installation. Phillips Petroleum Company at its Borger, Texas, and Kansas City, Kansas, refineries is installing additional polymerization capacity. Tide Water Oil Company, Bayonne, New Jersey, is building a large propane-butane rectification plant and is reported contemplating a polymerization unit. At Findlay, Ohio, National Refining Company is doubling its present capacity of 3,200 barrels through addition of a new atmospheric-vacuum distillation unit. Barnsdall Refining Corporation late in December, announced plans for a new Gulf Coast refinery of 10,000 barrels capacity, to be erected in the Corpus Christi, Texas, district.



Benzol-Acetone Dewaxing Plant, Socony-Vacuum Oil Company, Paulsboro, New Jersey. Rated at 3800 barrels per day, it is the largest dewaxing plant in the world.

COURTESY THE LUMMUS COMPANY.

SKIMMING PLANTS

The topping or skimming type of refinery continues to remain in the picture to a marked degree. At the beginning of the year there were 252 topping plants reported and an additional 15 building. Of the 252 reported 182 were shut down, leaving 70 in operation and 15 building. During the past 12 months 12 more skimming plants have been erected, which would indicate that about 95 to 100 such plants are operating. Despite the ever-increasing demand for high-octane motor fuel which the skimming plant can not produce save where freak crudes are available which produce either high-octane motor fuel or exceptionally large percentages of gasoline, and despite the low operating margin between crude prices and prices for finished products, the skimming or topping plant continues to prevail. With higher prices for furnace oils and fuel oils these plants can apparently be operated at some profit in certain territories, but the establishment of these small plants has not been restricted to any given area where a set of conditions exist which points to profitable operation. Many of them are modern efficient installations, and several, no doubt, plan erection of cracking facilities in the near future in order to get themselves in position to compete in the high-octane, higher-priced motor fuel markets.

Sixteen skimming plants were erected in Texas during 1936, 5 of these being in the Corpus Christi district, 3 at Gainesville, and 1 at Pettus, Bay City, Baldridge, Stamford, Sweetwater, Port Lavaca, Hondo, Mount Pleasant and McAllen. Oklahoma has 1 new skimming plant, at Lawton, which was moved there from the Oklahoma City field. In California new plants were erected at Huntington Beach and Long Beach. In Michigan new skimming plants were erected at West Branch, Drayton Plains, and Detroit. In Louisiana the new Rodessa field attracted 3 new plants, and Shreveport got 2. Establishment of new skimming plants in the East Texas field and

in the Oklahoma City field, both of which had plenty of them two years ago, has been notably absent. Both fields are left with a residue of relatively strong independent plants, practically all of which are equipped with cracking facilities.

If, however, the industry in boasting of its enterprise and technical developments brings forth the information that crude oil distillation in these days is most efficiently done in tube stills, then perhaps attention should be called to the fact that the industry reports to the Bureau of Mines only 727 pipe stills at the beginning of 1936, with only 11 building at the time, and further, with only 435 of these tube stills operating on crude. The capacity of these stills is just a little more than 2,000,000 barrels. With refinery operations running around 3,000,000 barrels per day, it is seen that between 30 and 35 percent of all crude oil charged to stills is being processed in shell still batteries, and many of these are of ancient vintage. And by far the larger number of these shell still batteries are being operated by the major refining concerns. Where such conditions exist, however, the usual procedure is to install a modern combination skimming, cracking and reforming unit of large capacity, thus taking the step from the oldest method to the newest at one time.

Foreign Construction

JUST as the United States maintains its lead in refining capacity and in cracking capacity, as well as in a number of refineries, this country continues to lead in plant construction, expansion and general improvement programs. Although there are 42 other countries where refineries are located, the total number of plants is but about 300 in all those countries, as against around 650 in this country. Admitting that in this country about 200 plants are inoperative, the discussion can not be furthered for the reason that no figures are available covering inactive plants in foreign countries. The capacity figure of roughly 4,000,000 barrels per day domestically, compares with the reported total capacity of foreign refineries of slightly over 2,000,000 barrels per day which gives incidentally, a world total of just over 6,000,000 barrels refining capacity per day.

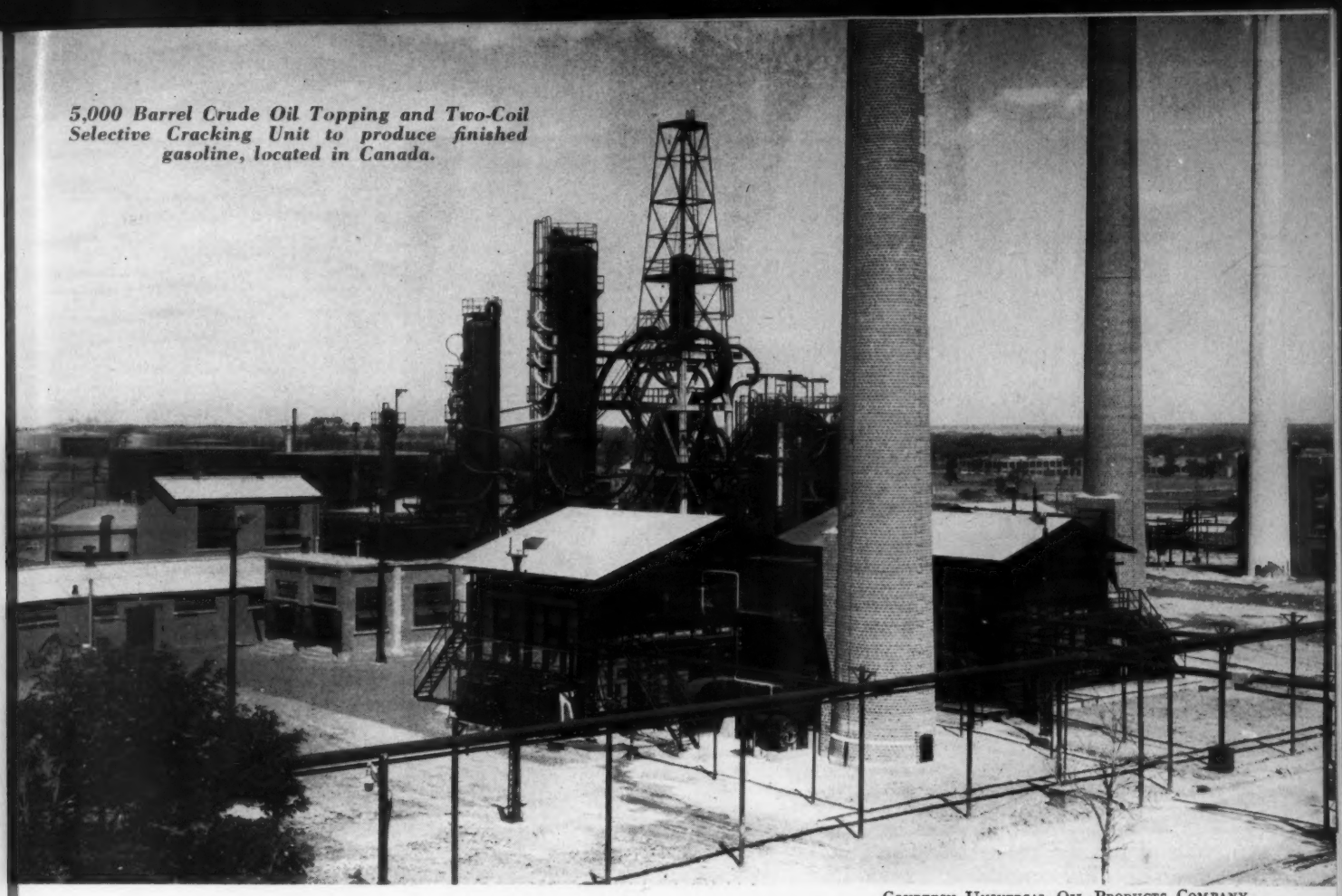
Foreign refineries operated about 650,000 barrels daily capacity represented as cracking units. The United States refining industry operates about 2,250,000 barrels of cracking capacity, or over three times as much cracking capacity as the rest of the world. Likewise, the United States is forging far ahead in polymerization capacity, just as it has done in capacity of both solvent refining and solvent dewaxing processes.

Domestic refining companies always adopt the newer process developments and apply them to their refining problems much more speedily than do their foreign competitors. This is obvious in regard to cracking, proved further in regard to solvent-refining methods and again in regard to polymerization. That it will again be true with regard to the various catalytic processes soon to become available is certainly true. Hydrogenation is the only modern development which has not been used to marked extent in this country, and its adaptation in such countries as Germany and England is occurring because of an entirely different set of economic conditions which make possible the profitable operation of the process.

Because of the recent rapidity of action on the part of several foreign countries toward the establishment of petroleum refining industries, it has been assumed by some commentators that perhaps around 50 percent of refining process construction during the next decade would occur abroad. The foregoing figures of capacity certainly disprove this. With two thirds of the world's refining capacity and with around three fourths of the world's cracking capacity, the United States is certain to be the scene of the major work in construction, improvement and expansion of refining facilities for many years to come. The second important factor pointing to the United States as the major market for refining processes and equipments, is the rapidity with which the American industry purchases and installs all newly developed modern refining processes. It is estimated therefore, that if the refining industry continues to spend around $200,000,000 annually for processes, equipment, maintenance and materials, about 25 percent of this will be spent abroad, and the remainder in this country.

It must be borne in mind in this connection that practically all of the foreign installations are engineered and are designed in the United States, and much of the equipment used in foreign construction work is of American make. This condition is just the reverse of the picture as of some 20 years ago, when it was generally considered for example that most European processes and systems were far in advance of American practice. Today, American engineering and chemical engineering is used in practically all refining countries throughout the world.

During the past three years the establishment of new refineries and the modernization of older plants has been especially marked in many foreign countries. The French have established a most modern refining industry within their country's borders, and following completion of distillation and cracking facilities embarked on an important program of construction of solvent processes for lubricating oil manufacture. Not all of this work has been completed. The German refineries, for the most part, have



5,000 Barrel Crude Oil Topping and Two-Coil Selective Cracking Unit to produce finished gasoline, located in Canada.

COURTESY UNIVERSAL OIL PRODUCTS COMPANY.

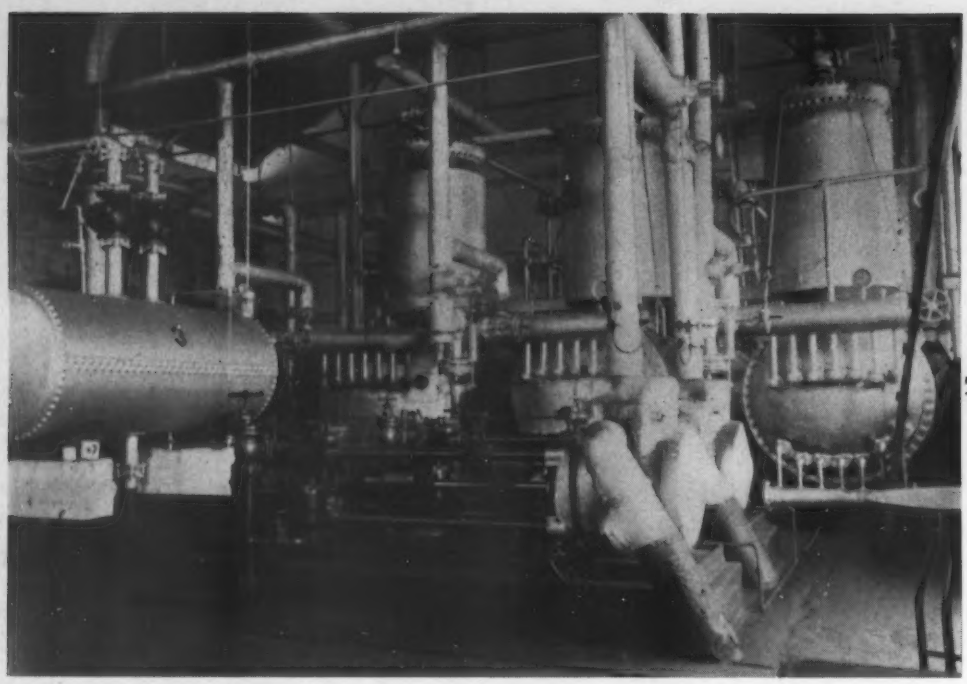
been rehabilitated and some new plants erected, and in that country most of the work is completed. The Italian program for establishment of a petroleum refining industry in its boundaries is now well underway, but two or three years more will be required to finish the work if original plans are carried out. Wartorn Spain has done little during 1936 but with return to anything like normal conditions it is expected that the original plans will be resumed. England has seen the modernization of most of its important refineries during the past two years, with considerable work now being underway. The U. S. S. R. continues to enlarge its refining operations in practically every region and proposes to remain active in modernization and establishment of refining plants for both gasoline and lubricants. Japan reports that its refining industry consists of 69 refineries and 8 gasoline plants, and there is now some work going forward in that country. In South America the most active countries are Uruguay, Ecuador and Venezuela, with continued construction at Aruba and Curacao, Dutch West Indies.

Practically all of the foreign work, with the exception of that being done for lubricating oil manufacture specifically, consists of cracking facilities and this chiefly of the modern selective cracking or combination type of operation. Many of the foreign plants have made the step from shell still operation to combination cracking and skimming units without the intermediate step of tube-still distillation for topping work and separate cracking units which, for the most part, has been the American experience in development.

In addition, many of the foreign installations have been of large capacity. This is notably true at Abadan, Iran, where Anglo-Iranian Oil Company, operating the world's largest refinery, with capacity reported at 270,000 barrels per day, has installed two crude oil distillation units handling 65,000 barrels per day each. In addition this plant operates some 35,000-barrel per day redistillation units. Cracking here consists of 8 low-pressure units, 4 high-pressure naphtha reforming units, with total capacity of 90,000 barrels.

Foreign refineries total about 300 plants located in 42 countries and with around 500 plants in the United States, there is a world total of 800 plants. Of the 300 foreign plants only 100 in 29 countries are equipped with modern cracking facilities. It is true that many of the remaining 200 foreign refineries are small and in all likelihood will never develop into cracking type of operations. However, with continued recovery in business conditions throughout the world, it is thought that about 50 percent of those not now cracking may logically be expected to ultimately install such facilities. Motor fuel demand in most countries is increasing. Refiners find the need for cracking facilities because cracking secures more motor fuel without increasing crude oil charged to stills. The trend toward higher octane ratings is also influencing the cracking unit installation situation in many countries. Further, much of the foreign crude yields straight-run gasoline with low-octane rating, so naphtha reforming has become popular and expedient. Another influencing factor is that the cracking unit reduces viscosity of residual oils giving them easier marketability, especially during the colder months.

In the following list of construction activities in foreign countries nothing is included but the major construction programs now actually under way. It is thought that this list is but a partial summary of existing construction conditions in as much as it includes only those jobs which have been reported in the press recently and it is known that some companies and some countries are not giving publicity to such construction because of the current delicate



Refrigeration system for wax plant. Compania Mexicana de Petroleos "El Aguila" S. A. Tampico, Mexico.

political situation abroad. It is estimated that the following reports cover a total of $15,000,000 to $20,000,000 involved in refinery process equipment construction in foreign countries. The coming year will certainly see a like amount of expenditures indicated by construction programs to yet be announced.

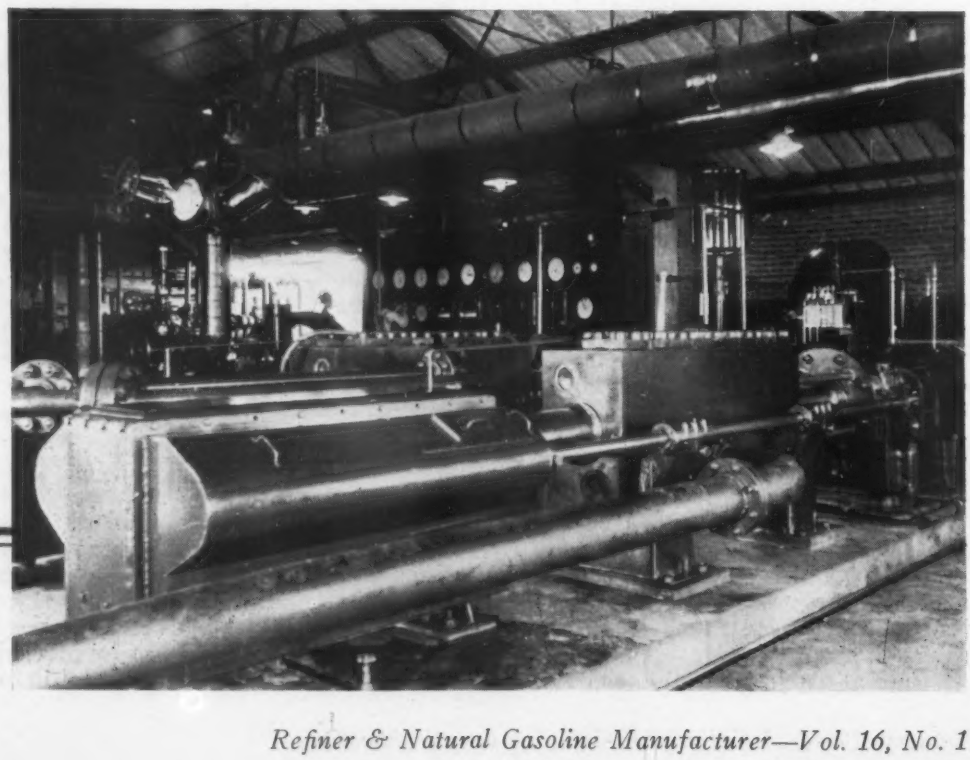
PLANTS UNDER CONSTRUCTION

Curacaosche Petroleum (Royal-Dutch Shell) in Dutch West Indies, at Curacao, which has been actively engaged in expansion and modernization during the past three years, recently carried the work further through completion of two Dubbs cracking and naphtha reforming units totalling 17,000 barrels capacity.

In Venezuela Socony-Vacuum Oil Company, (Standard Oil Company of New York) in arranging for concession of 1,500,000 acres, has agreed to erect a large refinery in eastern Venezuela. In the same South American country, Standard Oil Company of Venezuela (subsidiary of Standard Oil Company of New Jersey) also has agreed to erect a large refinery (reported at 20,000 to 25,000 barrels capacity) in eastern Venezuela.

The French government has granted a refining concession to Compagnie Petrolifere Starnaphtha and this concern will erect a plant near Marseilles to operate on Roumanian crude. Standard Franco-Americaine at Port Jerome, France, is reported planning erection of a new propane dewaxing plant. Raffinerie de Petrole de Nord at Dunkerque, France, is installing a 500-barrel per day Benzol-Acetone (Solvent Dewaxing Process) employing continuous vacuum type filtration equipment.

Raffineria de Napoli, S.A.I., Naples, Italy, is installing a 525-barrel per day Benzol-Acetone (Sol-



Control and pump house for cracking unit. Compania Mexicana de Petroleos "El Aguila" S. A. Tampico, Mexico.

vent Dewaxing Process) designed to operate on Duo-Sol refined stocks. "Aguila," S. A., Technicol-Industriale, Trieste, Italy, is doubling capacity of its 10,000-barrel plant and installing modern cracking and distillation facilities.

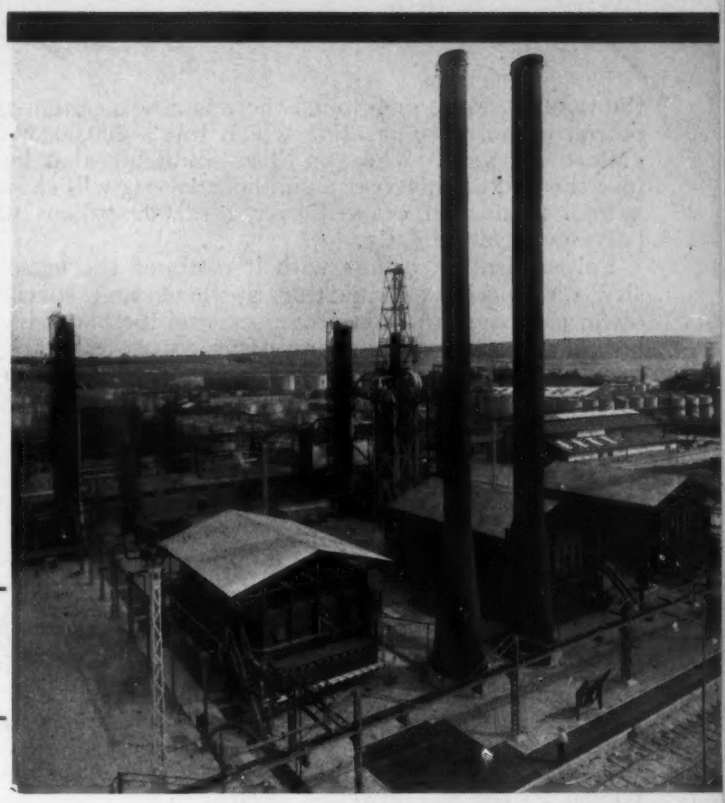
Shell-Mex and B.P. Ltd. at Shell Haven, England, has under construction a Benzol-Acetone (Solvent Dewaxing Process) plant which is to charge 1,510 barrels per day of furfural refining distillates of varying specifications. National Oil Refineries, Ltd., Llandarcy, near Swansea, South Wales, is erecting an 8,750-barrel combination atmospheric-vacuum distillation unit, for completion in the summer of 1937. Irish National Refineries, Ltd., is building a modern refinery near Dublin, Irish Free State, for completion in 1937.

Gewerkschaft Deutsche Erdol Refineries, Hanover, Germany, now has under construction a lubricating oil refinery which will employ Coubrough vacuum distillation, furfural solvent refining, clay contacting and Benzol - Acetone (Solvent Dewaxing Process) dewaxing, with capacity of 1,600 barrels per day.

The Bahrein Petroleum Company on the Island of Bahrein, Persian Gulf, now building, was originally designed for 10,000 barrels per day, but plans have been changed and the plant capacity enlarged to 20,000 barrels.

Asano Bussan Company, Ltd., Tokyo, Japan, is building a new Coubrough type vacuum distillation unit for operation on California crude from Poso Creek field.

U.S.S.R. recently placed orders in the United States for one installation of contact clay processing system, one Duo-Sol solvent refining process and one unit of the Bari-Sol process. The Soviets will continue installation of new pipe still distillation facilities and cracking units.



A Dubbs Cracking Installation in France.

COURTESY UNIVERSAL OIL PRODUCTS COMPANY.

Administracion Nacional de Combustibles, Alcohl y Portland, Montevideo, Uraguay, is completing erection of a 5,000-barrel refinery and a 1,200-barrel cracking installation.

Petroleos de Mexico, S.A. (Petromex), Mexican Government-owned refinery, is building a 3,000-barrel selective type cracking unit for completion later this year.

Polymerization

AFTER three or four years of more or less secret development work the industry began hearing of commercial polymerization early in 1935, at which time the formation of licensing companies was announced and results were published dealing with a commercial catalytic-polymerization unit operation. During the past two years petroleum literature has been replete with design, construction operation and technical information. The coming year will see much more of the technology of polymerization as well as practical operation information.

Adoption of the "poly" process by the industry so speedily following its proven utility in commercial capacities is but another indication of the rapidity of technical progress on the one hand, and of the willingness on industry's part to accept and to use to best advantage such technical development, on the other.

Something of the widespread interest in polymerization practice is indicated in Dr. Egloff's remarks before the last American Petroleum Institute convention (see REFINER, Vol. 15, No. 12, Dec. 1936, page 544). In his address Dr. Egloff stated that a number of catalytic polymerization units in commercial operation, in course of construction, design or projected, which range in capacity from 600,000 to 27,000,000 cubic feet of cracked gas with propene-butene contents ranging from 14 to 41 percent. Fifteen units were tabulated. When these units are in commercial operation there will be a daily production of 545,000 gallons of polymer gasoline, with an octane rating from 81 to 100, from 102,200,000 cubic feet of cracked gas. The yearly production of catalytic-polymer gasoline will be at the rate of about 200,000,000 gallons. He stated further that it was estimated at that time that the unitary thermal-polymerization process producing polymer gasoline from cracked gases, had under operation, construction, or design a productive capacity of about 300,000 gallons per day, or at the rate of about 100,000,000 gallons per year. Thus, for

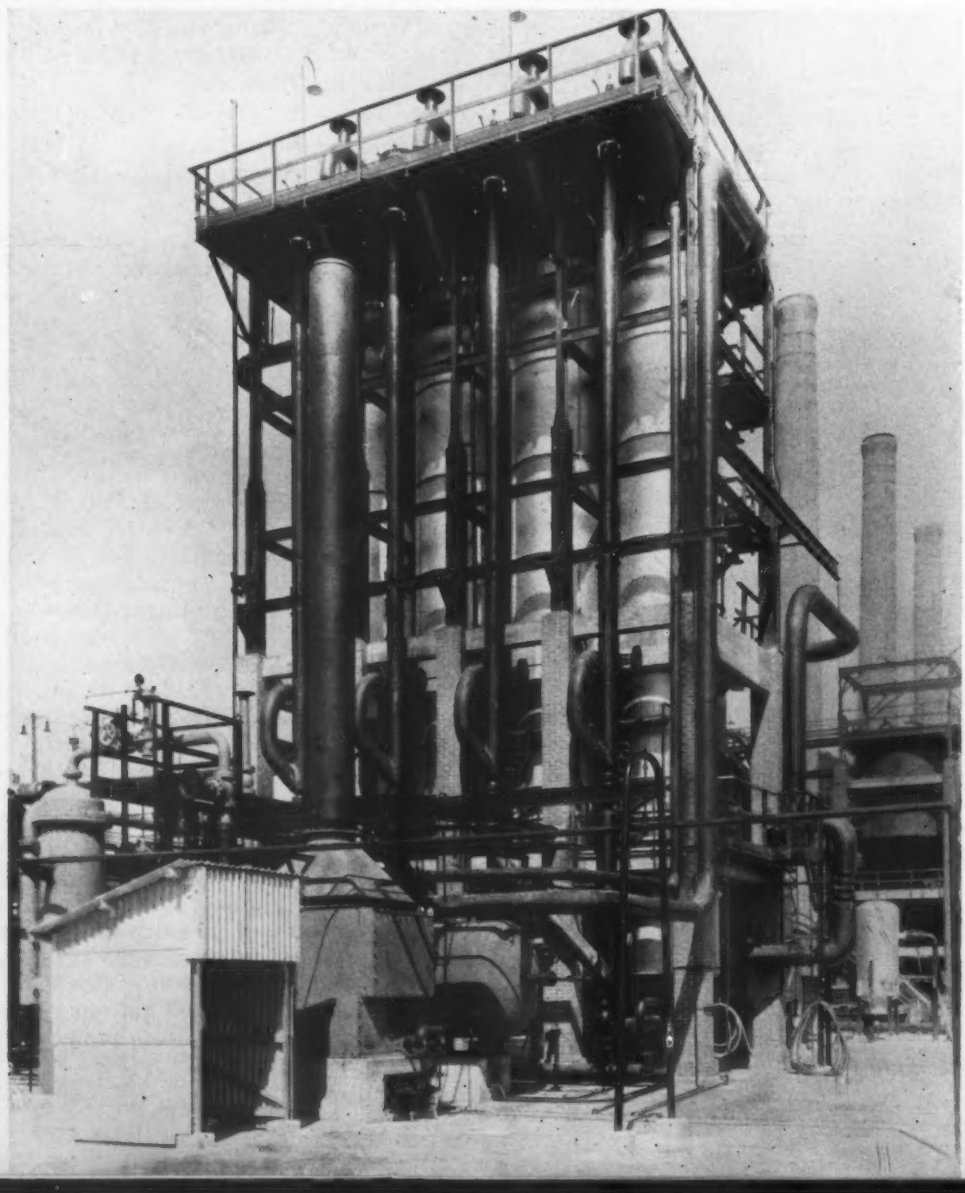
the two processes mentioned there is now a potential output of polymer gasoline which totals 300,000,000 gallons per year. There is little doubt but that before the end of this year a similar analysis will show a total production of well over 1,000,000 gallons of polymer gasoline daily.

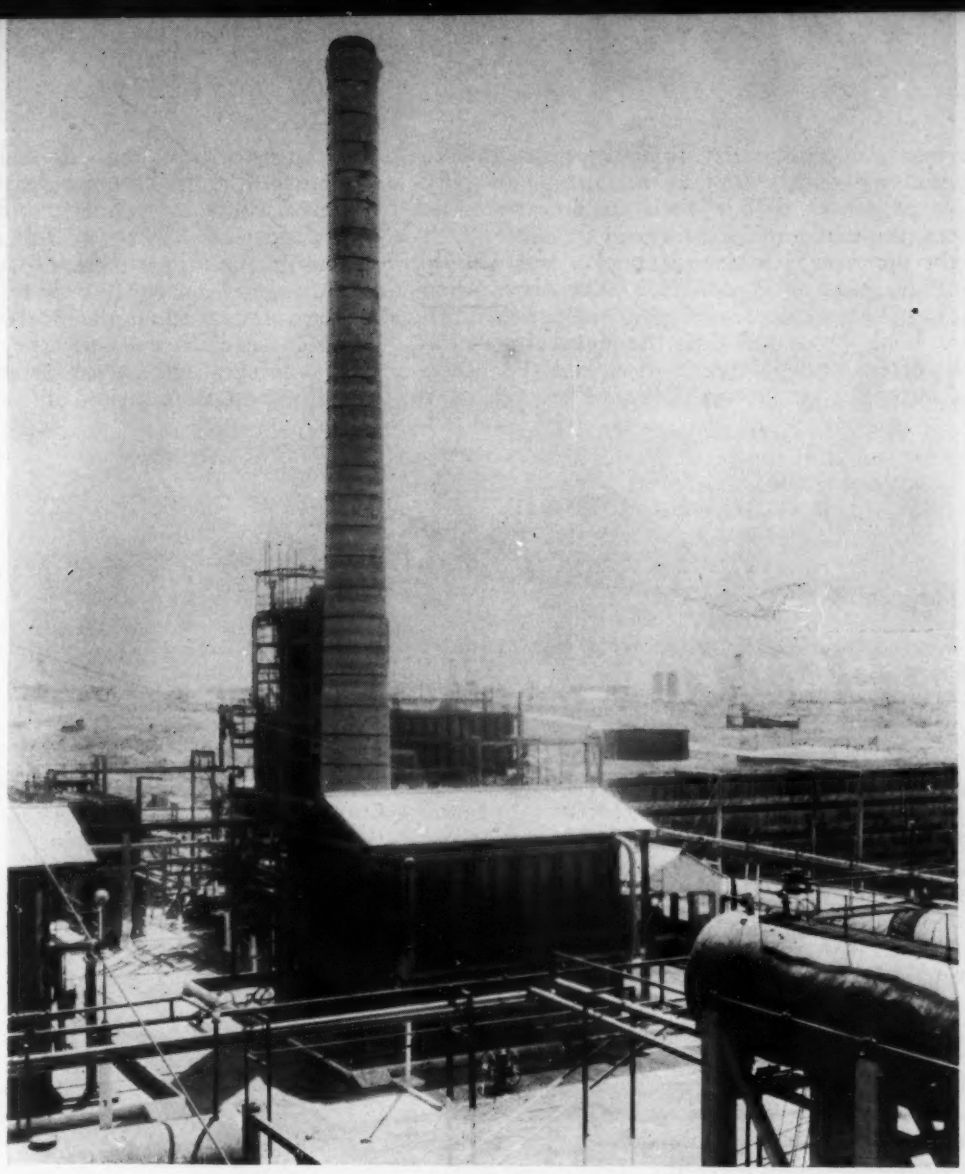
Polymerization brings with it ofttimes the necessity for special stabilization systems, and special olefin gas concentration processes, and further it has brought about the perfection of processes for cracking the propane and butane hydrocarbons or processes for catalytically dehydrogenating them into the corresponding propene and butene. This because the olefinic hydrocarbons are adapted to easier conversion into the desired polymer liquids. Thus, where it is desirable to polymerize to the olefins, it is sometimes desirable to increase the concentration of such hydrocarbons and thus secure higher yields of polymers. Other processes are available to process the paraffin hydrocarbons along with the olefins. However, the point here is not one of technology but one of economics, and if, as apparently is the case, it is economically sound to operate the polymerization processes, then the refining industry is going to continue with rather rapid installation of the presently available processes. This is not only true in the United States, but inquiries regarding these processes from practically every refining country abroad indicates a similar lively interest in the subject in foreign countries. Around $20,000,000 will be spent in the construction of these new processes during the current year, it is believed. Installations cost from $500,000 to $1,500,000 each.

It has been said that a refinery should have from 3,000,000 to 5,000,000 cubic feet, or more, of gas per day in order that it be good economics to go into polymerization work. Apparently something is wrong with those figures or with their originators, for obviously they are in error. Egloff reports one unit charging 600,000 cubic feet of gas daily, yielding 5.3 gallons per 1000 cubic feet, or 3,180 gallons per day. The percentage of propene and butenes in the gas influence the economy of polymerization to a marked degree. Another unit charging two million cubic feet of gas daily, secures a yield of 4.9 gallons per thousand, or a total of 9,500 gallons per day. Still another unit charging 5,000,000 cubic feet of gas daily, secures but 3 gallons of polymers per thousand cubic feet, with a total yield of 15,000 gallons daily. Thus, it becomes apparent that no set production of gas per refining can be used as a measuring tape insofar as economy of polymerization work is concerned. Each refinery, or better still, each battery of

Catalytic Polymerization Unit processing 8,000,000 cubic feet of gas per day.

COURTESY UNIVERSAL OIL PRODUCTS COMPANY





Unitary Thermal Polymerization Process Installation.

COURTESY M. W. KELLOGG COMPANY

cracking units becomes an individual problem. It is very probable that if a refinery makes above 500,000 cubic feet of gas daily, which is reasonably well rich in propene and butenes, it will pay that refinery to investigate the merits of a polymerization plant especially engineered to suit its peculiar needs. It is obvious, however, that the larger the gas production per refinery the easier it will be to fit polymerization into the scheme of things and with good economy.

Combination units are being designed, one of which is under construction in the Texas Panhandle for operation on gasoline plant stabilizer overhead consisting mostly of propane and butane. These units combine gas cracking with catalytic polymerization, employing thermal means for producing the unsaturates required for charging to the catalytic process.

One of the recent developments with regard to polymerization is the production of new lubricants. This involves the catalytic polymerization of high-olefin fraction of cracked gasoline to produce an oil with high viscosity index, a low Conradson carbon and a high resistance to oxidation. A small percent of this product, it is said, when added to lubricating oil of 100 viscosity index, raises the index to 126, and also increases the life of the lubricating oil so that consumption is reduced by about 40 percent. The catalytic polymerization of isobutene from cracked gases, it is said, produces an oil of high molecular weight and viscosity, suitable for blending with lower-grade lubricants to improve their wear quality in motors.

Polymerization at the present writing appears chiefly concerned with the utilization of propane and butane, or with propene and the butenes. Sufficient quantities of these hydrocarbons are available from refinery gases, cracking-unit gases, and natural gasoline to produce enormous quantities of polymer liquids. One estimate recently published was 4,500,000,000 gallons per year, or more than 25 percent of the total gasoline consumed in this country, yet still another estimate placed total potential polymer gasoline available at 9,000,000,000 gallons per year. Either figure represents an enormous potential, and either interesting figure is indicative to some extent of the work which the industry will do in making use of the newer processes now available.

Just what effect polymerization will have on the refining industry as it concerns the natural gasoline industry and that industry's future is a moot question. There has been a great deal of discussion regarding the pros and cons of this problem with some

technologists and economist insisting that the refining industry's efforts to take advantage of polymerization processes will in little or no way affect the refiners' requirements for natural gasoline. Others take the opposite view (see REFINER, Vol. 15, No. 12, Dec. 1936, page 535) and fear that polymerization will bring about decreased demand for naturals, and this school advocates that the natural gasoline manufacturer turn to polymerization and the preparation of competitive motor fuels. Then, there is the matter of liquefied petroleum gases and the price structure for this commodity and which is manufactured both by refiners and by natural gasoline manufacturers. Some would sell the paraffins, polymerizing the unsaturates; others would crack the paraffins to unsaturates and polymerize all. Time and economics must decide these matters. Further along in these discussions the matter of polymerization as it may or may not affect the natural gasoline manufacturer is presented in more detail.

Cracking

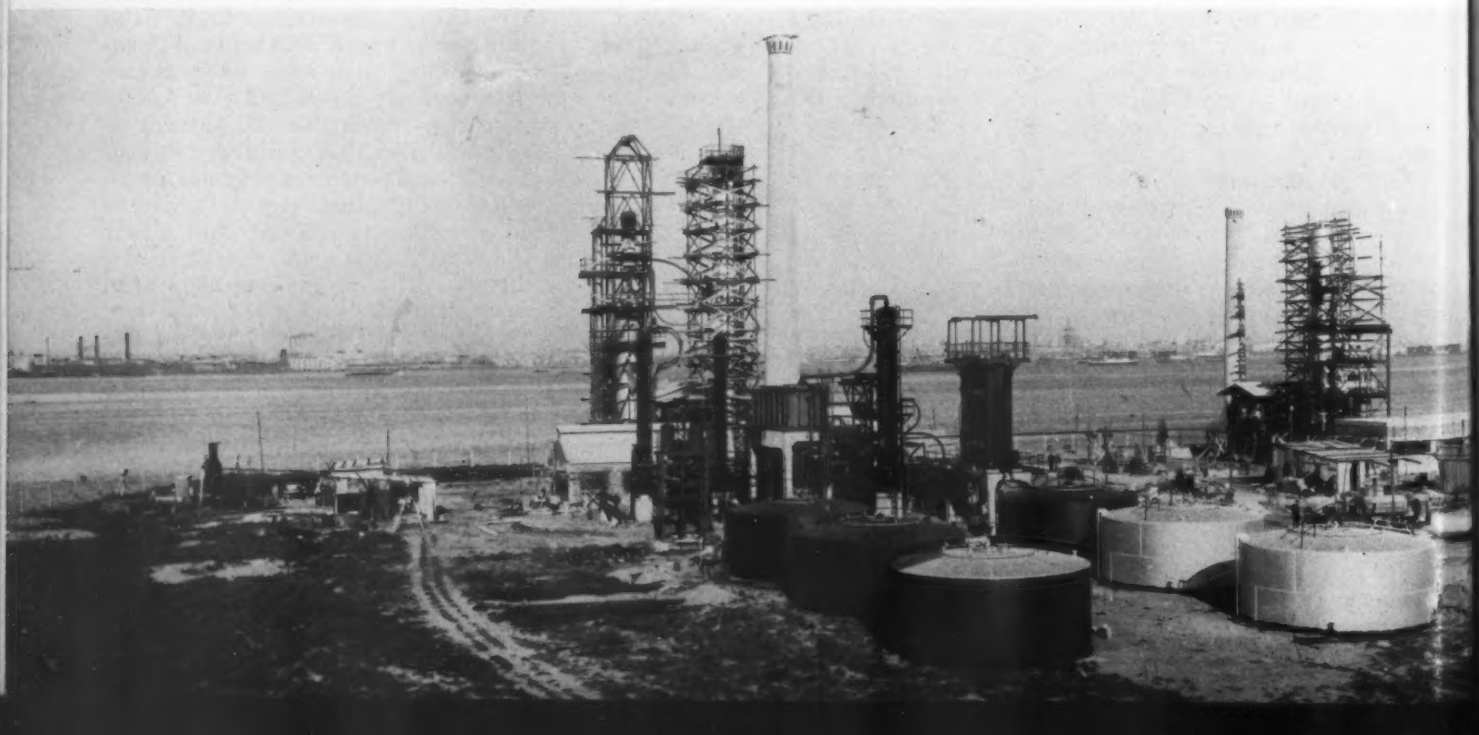
OF chief importance among the factors contributing to activity in cracking-unit construction and modernization, has been the lack of balance between skimming facilities producing relatively low-octane rating straight-run gasoline and cracking facilities needed for the production of high-octane rating motor fuel. The condition of unbalance remains in several refining districts in this country and in several foreign countries. Another factor of similar importance is that of obsolescence of existing cracking units, and still another important factor is the ever-present enemy of equipment—corrosion.

Currently there is important activity in construction of individual cracking units, and the combination unit, or multiple-coil selective cracking systems, which skim and crack simultaneously. Further, refiners have found that units for reforming naphtha aid more materially than was once thought for the reason that reformed products in addition to having better anti-knock characteristics, also give better mileage. With polymerization available to secure high yields of higher anti-knock gasoline and with admitted need for additional cracking facilities as well as replacement of worn units, it is certain that current activity in construction and modernization will be continued for the next several years.

The trend is in two directions. First, the large refining with ample finances is erecting the exceptionally larger combination units to skim, crack, and reform simultaneously, and in capacities ranging from 15,000 to 20,000 and to 30,000 barrels of crude per day. The other trend is toward installation of small units of around 750 barrels capacity. These have recently been perfected and are especially adaptable to the financial and other needs of the smaller refining concern. They can be installed at prices ranging from $75,000 to $150,000, roughly speaking, and recently several have been erected. It is known that a few concerns are planning erection of similar units. Thus the field is divided between units costing around $100,000 and large units costing from $1,000,000 to $2,000,000 and upward.

In addition there has been rather extensive activity in revamping, remodeling, and modernization of existing cracking facilities, but this is chiefly of a temporary nature, it is thought, and companies so

Administracion Nacional de Combustibles, Alcohol y Portland, at La Teja, on Montevideo Bat, Uruguay, South America, is nearing completion of its new refinery



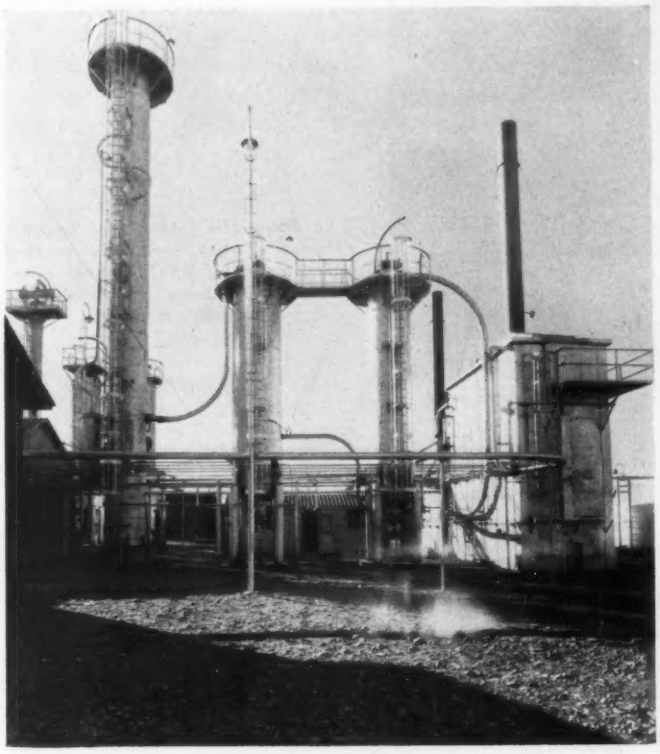
engaged have been merely waiting for improved economic conditions before replacing their obsolete equipment with the presently available more modern, scientific processes. In general, and as a whole, the cracking field has been exceptionally active during the past year, and it may be safely predicted that such activity will continue for several years to come.

Because of constant technical improvement in cracking, because of the severity of the service, obsolescence and "old age" are very important factors in cracking work. The combination unit as now developed will, in the next few years be further improved and with more widespread adoption (which is certain to come) it will replace most of the present strictly cracking units. Since the service is severe, corrosion is speedy, and improvements in efficiency very rapid, the work of replacement must certainly continue from year to year.

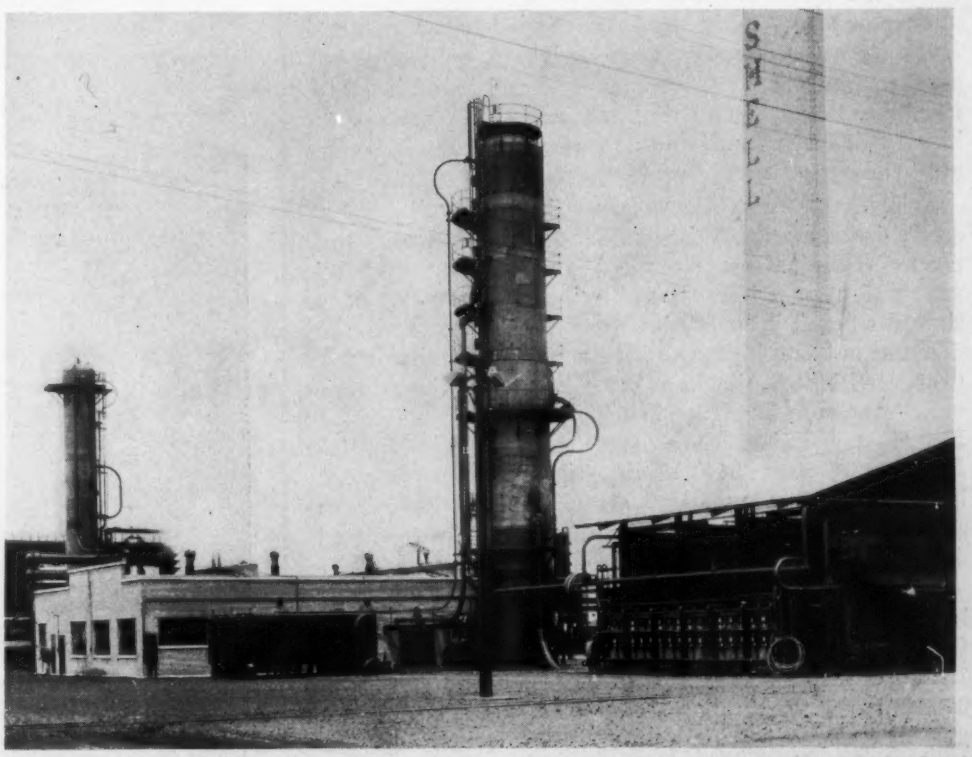
The refining industry actually requires an average of 60 percent cracked gasoline as against 40 percent straight-run gasoline at the present writing, but to meet such a condition a large number of cracking, reforming, polymerization, and combination systems must be installed.

It is interesting to note the widespread use of cracking in this country as compared to the rest of the world. Cracking capacity in the United States is practically 50 percent of total crude oil charging capacity. For the remainder of the world, cracking capacity is but about 25 percent of the total crude oil charging capacity. A study of the list of refineries and cracking units in foreign countries will show very few countries where cracking is used to the extent that it is used here. Total refining capacity is reported at approximately 6,000,000 barrels per day and 4,000,000 barrels of that is in the United States. Total cracking capacity is estimated as close to 2,650,000 barrels per day, and of that amount a little over 2,000,000 barrels capacity is in this country. Thus we have a total foreign refining capacity of around 2,000,000 barrels with just over a half million barrels of cracking capacity.

The improvements, in cracking facilities, in cracking technique and in operation during recent years have been very well summed up and discussed by R. P. Mase before a recent meeting of the Western Petroleum Refiners Association. (See the REFINER, Vol. 15, No. 11, Nov., 1936). The author's conclusions were that in brief summary it should be said "That topped crude is the most common cracking

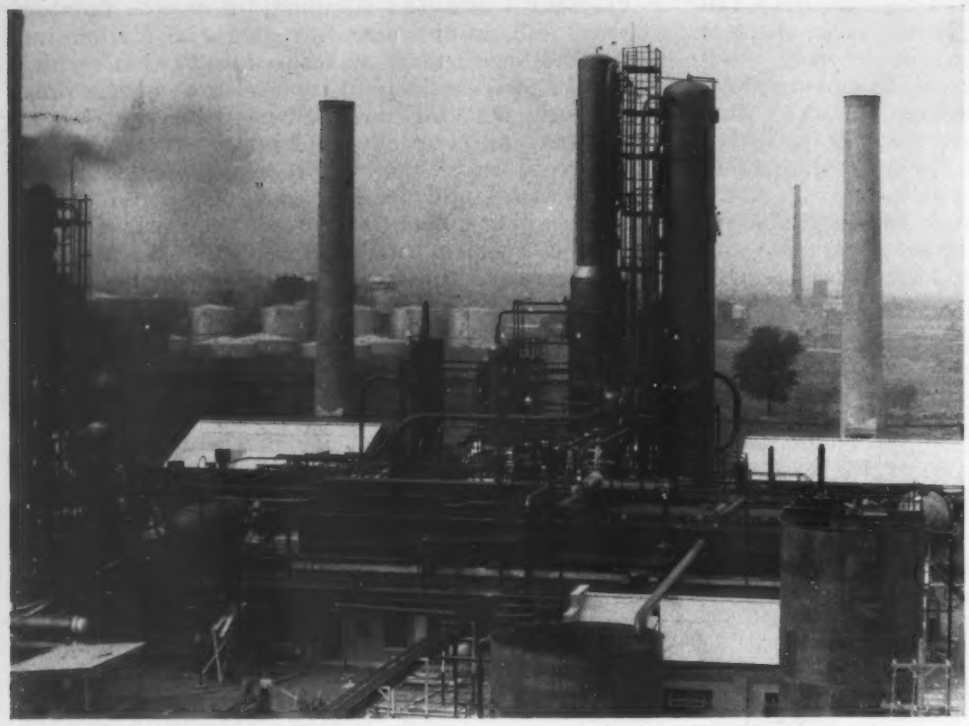


The two-coil selective Dubbs cracking unit, Home Oil & Refining Company, Great Falls, Montana. Designed and built by The Ralph M. Parsons Company.



13,000 barrel gasoline prefactionator and naphtha cracking unit.

COURTESY UNIVERSAL OIL PRODUCTS COMPANY.



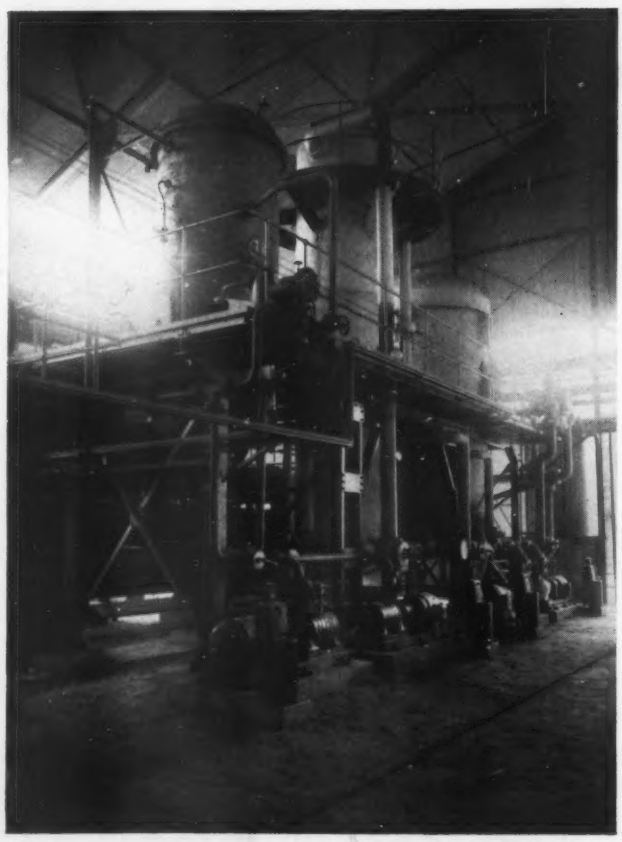
The Pure Oil Company, Toledo, Ohio, refinery, recently started operating the 8,000-barrel combination topping and cracking unit shown above.

COURTESY THE LUMMUS COMPANY.

stock for cracking plants in the Mid-Continent area. That putting the whole charging stock through the furnace coil is being practiced increasingly, because of higher yields of cracked gasoline result. Also a better fuel oil. Two coil operation is a desirable development since high-octane gasoline results. Low first cost of units is being achieved, not by cheapening construction, but by simplification and improved design. Important developments in tube furnaces have been achieved. Fractionation is being carried out at more favorable pressures. Controlled heating curve for light coil and high velocity low time exposure of heavy oil in the furnace give better results. Open type condensers and coolers are being successfully used. Vapor-recovery and stabilization equipment has been simplified and effectively combined with cracking units. Polymerization is probably the next logical development."

One of the finest pieces of work now available for study is of an analytical and economic nature, and traces technical development in cracking and its vast and almost immeasurable influence on not only the petroleum industry but on all industry. It is the discussion "Cracking and its Economic Significance," presented before the Refining Division of the American Petroleum Institute in Chicago in November, by Dr. Gustav Egloff (See REFINER, Vol. 15, No. 12. Dec., 1936, page 544). This study answers a very large number of questions which readers have been asking, for it brings to date a number of inter-related developments in a variety of fields of endeavor.

The importance of cracking was recently discussed by Joseph E. Pogue before the International Power Conference, at which time he pointed out that in 1920 the output of cracked gasoline was only 15,000,000 barrels as compared to 101,000,000 barrels of gasoline derived from crude oil by distillation. In 1935 the production of cracked gasoline had risen to 208,000,000 barrels or nearly equal in volume to the 220,000,000 barrels of the straight-run product. Thus cracking has enabled the recovery of gasoline



Nederlandsche Koloniale Petroleum Maatschappij, subsidiary of Standard Oil Company of New Jersey, has installed the third Edeleanu installation at its Palembang, Sumatra, refinery. Feed capacity is 4,000 barrels of water-white distillate per day.

from crude oil to increase from 26 percent in 1920 to 44 percent in 1935, and the trend of increased recovery is till upward. In 1936 the Bureau of Mines reported "The trends of cracking capacities in 1936 were similar to those in several preceding years; i.e., the total capacity and the operating capacity increased, but the inoperative capacity declined. The total capacity of cracking units, expressed in terms of fresh feed charged daily, and including the capacity of the units under construction, increased from 2,229,269 barrels on January 1, 1935, to 2,240,768 barrels on January 1, 1936, virtually the entire increase being in plants under construction."

The cracking process has proven the source of materials upon which a number of chemical industries have been founded, which use the olefins produced by cracking. The oil industry is deriving more and more of its products by chemical synthesis. Some of the products are alcohols, anti-freeze fluids, various ethers, resins, rubber substitutes, acetylene, amines, chlorides, glycols, nitro-glycols, chlorohydrins, ketones, acids, esters, sulfolenes, and so on. A recent development is the commercial application of a process for the manufacture of sulfuric acid from hydrogen sulfide present in gases produced from cracking. The plant uses the phenolate process to produce relatively pure hydrogen sulfide which is oxidized to sulfuric acid. Thus the refining industry can supply its acid from one of its by-products.

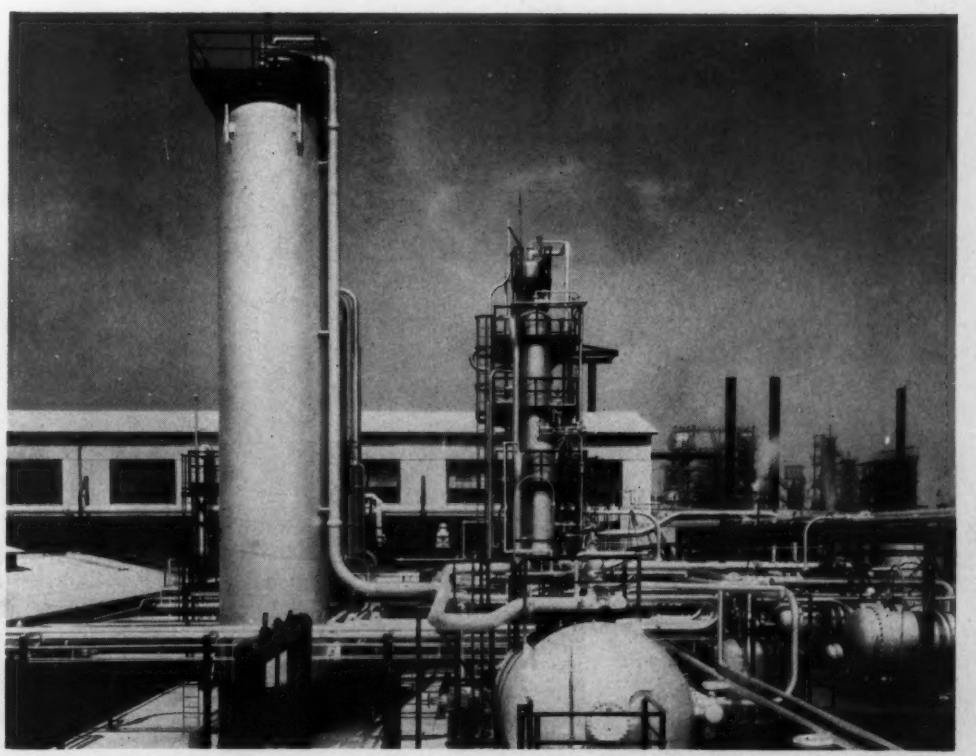
Solvent Processes

SINCE 1933 refining companies in the United States and abroad have been active in solvent process construction and late lists indicate a total of 54 such units in service. Several more are under design or construction or projected. It is estimated that about 50 percent of the potential capacity has been erected or projected which indicates continued construction activity for the next few years in this field.

In the solvent-extraction field there are reported 7 installations of the Furfural process; 2 installations of the Nitrobenzene process; 3 units of the Sulfur Dioxide-Benzol or Edeleanu process, which does not include the earlier straight sulfur dioxide installations; 8 units of the Chlorex process; 7 units of the Duo-Sol process, and 5 Phenol process installations.

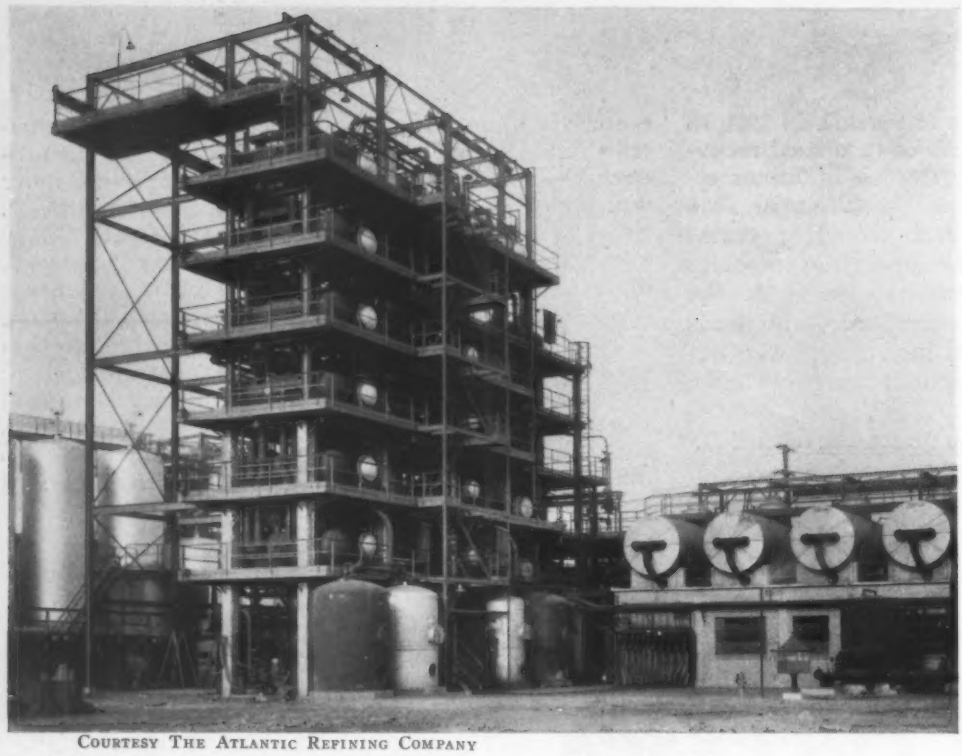
In the solvent-dewaxing field there is reported 14 installations of the Benzol-Ketone process (Solvent Dewaxing Process); 5 units of the Propane process; 1 Trichlorethylene installation, and 2 units of the Barisol process.

The total reported capacity of the solvent-extraction



Propane Deasphalting and Dewaxing Process Installation.

COURTESY M. W. KELLOGG COMPANY.



COURTESY THE ATLANTIC REFINING COMPANY

Installation of the Nitrobenzene Extraction Process.

processes is 60,150 barrels, while the total capacity of the solvent-dewaxing units now operating is reported at 31,870 barrels. Nine of the 32 solvent-extraction processes are operating in England, Germany, Roumania, France, Canada and Italy. Seven of the 22 solvent-dewaxing units are operating in England, Germany, France and Italy. Thus of the total of 54 installations, of both dewaxing and extraction processes, 16 units are located abroad and 38 are in the United States. This does not represent saturation of the market for such processes either in this country nor abroad.

The application of a solvent-extraction process to the commercial operation stage in separation of paraffins from naphthenes and aromatics in straight-run naphtha was one of the important developments during the past year.

An installation using Edeleanu solvents and processes with 6000 barrels capacity was installed for this purpose in the Gulf Coast refining district. Such work has been under way experimentally for some time, but the new installation mentioned marks the first commercial or plant practice. The plant uses the typical equipment generally employed with the

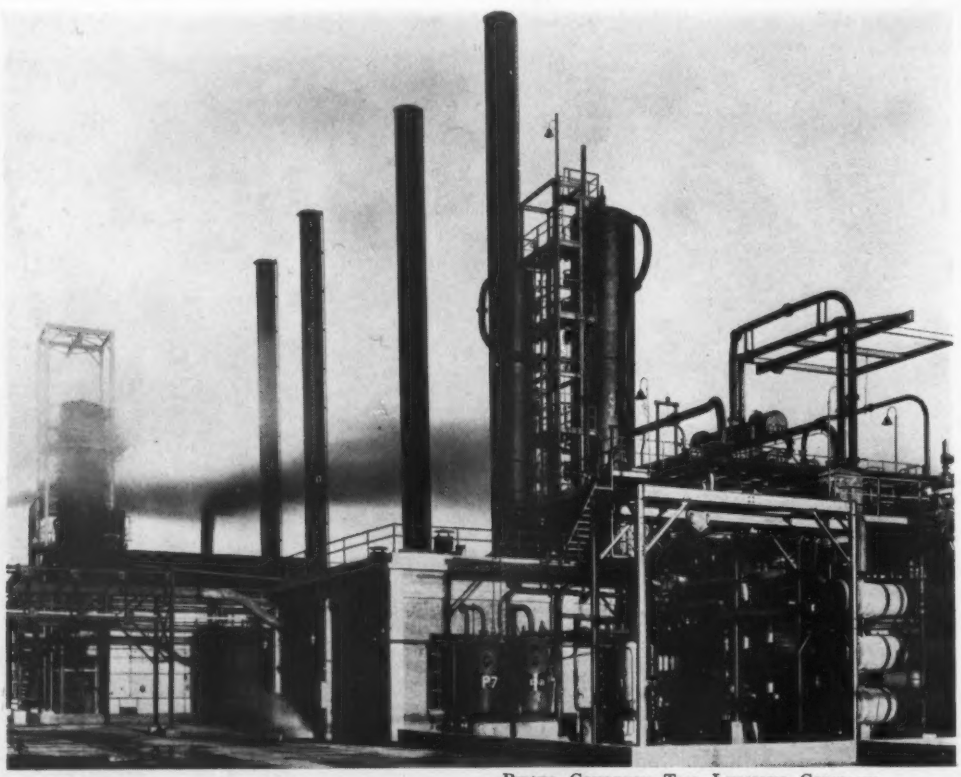
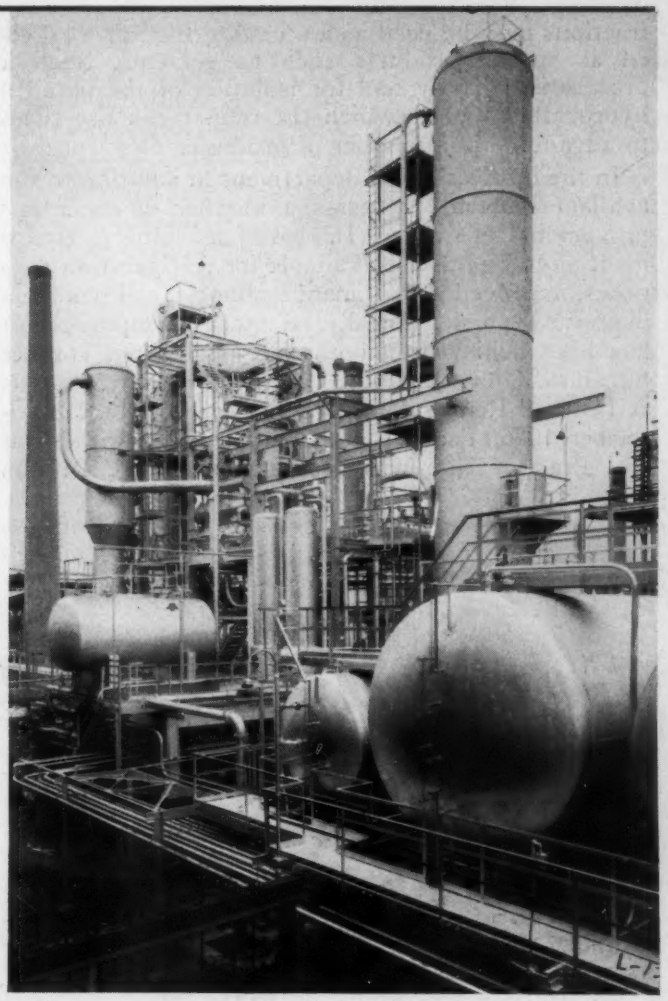


PHOTO COURTESY THE LUMMUS COMPANY.

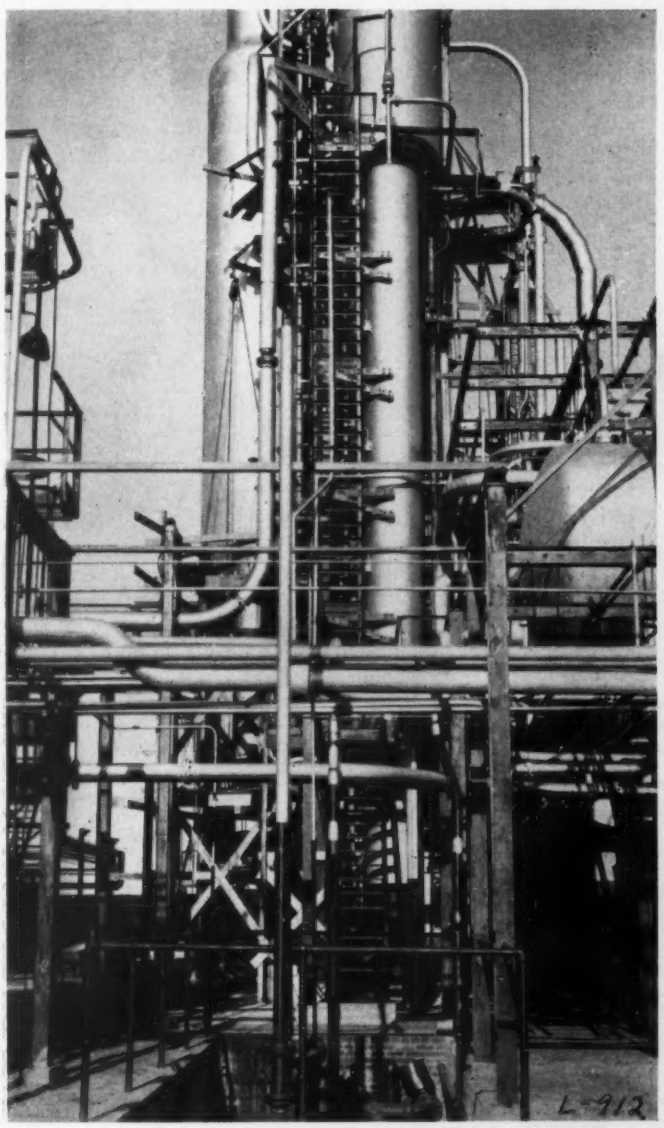
Herbert Green & Company, Ltd., East Halton, England, has a 1400 barrels per day capacity Duo Sol solvent plant.

Magnolia Petroleum Company, Beaumont, Texas, is operating a new 3,000-barrel per day Furfural solvent plant.

PHOTO COURTESY THE LUMMUS COMPANY



Edeleanu process with some variations from the lubricating oil unit necessitated because of the volatile characteristics of the naphtha charge. And ethane-propane system is used for indirect cooling of the naphtha and sulfur dioxide thus securing the low

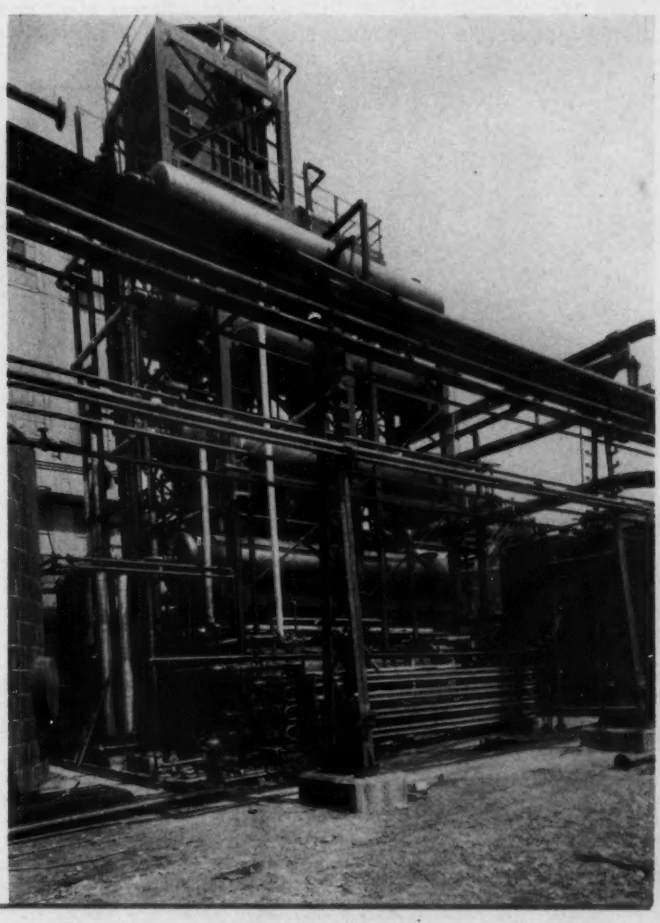


This Furfural solvent plant operates at 5,000 barrels per day capacity. Gulf Oil Corporation, Port Arthur, Texas.

PHOTO COURTESY THE LUMMUS COMPANY

temperatures required for successful operation—in the order of minus 60° F. it is reported.

The separated fractions have a number of uses. The paraffinic fraction can be reformed or cracked to higher-octane motor fuel, or it can be marketed as solvents or cleaners. The aromatic-naphthenic



Chlorex Solvent Plant, Freedom Oil Works, Freedom, Pennsylvania.

PHOTO COURTESY CARBIDE AND CARBON CHEMICALS CORPORATION

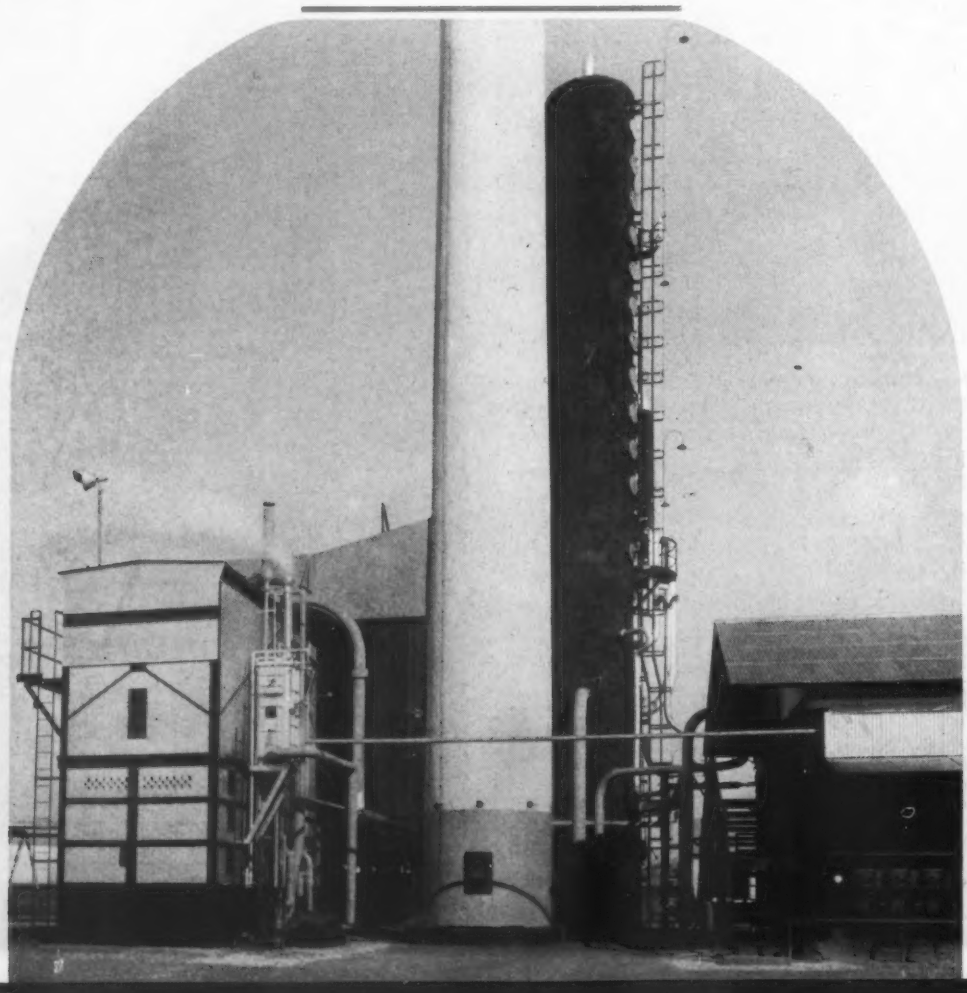
fractions may be used as a blending fuel, or marketed as special products such as solvents. Such a process is a handy tool for isolation of the paraffin hydrocarbons, after which the refiner can use them to advantage in a number of processes or purposes.

In the lubricating oil department in addition to the available solvent processes a number of other improvements are noted. Improved machinery, equipment and systems are available for refrigeration purposes, improved grease manufacturing facilities have likewise been developed, and marked improvement has been achieved in both percolation and contact filtration. Under the title "New Filtration Methods at Pennzoil Refinery," (REFINER, Vol. 15, No. 12, December 1936, Page 555) the new process called Filtrol Fractionation was described in detail. In this process a finely-divided clay is mixed into a slurry with the stock to be filtered, and the slurry is charged into a tube still for heating. The heated charge passes into the fractionation column, is flashed, and the unvaporized portion together with the contact clay drops to the bottom of the column from where it is removed by pumps. While still hot this mixture is filtered, the clay removed and the decolorized oil is ready for dewaxing and other processing steps. The process shortens total time for processing the oil, reducing the amount of equipment required, and eliminates percolation methods, and decolorizing efficiency is increased by the method. Costs of reheating the oil for filtering, and for diluting with naphtha and subsequent recovery of the diluent, are eliminated. The two commercial installations of this filtering process have attracted much attention.

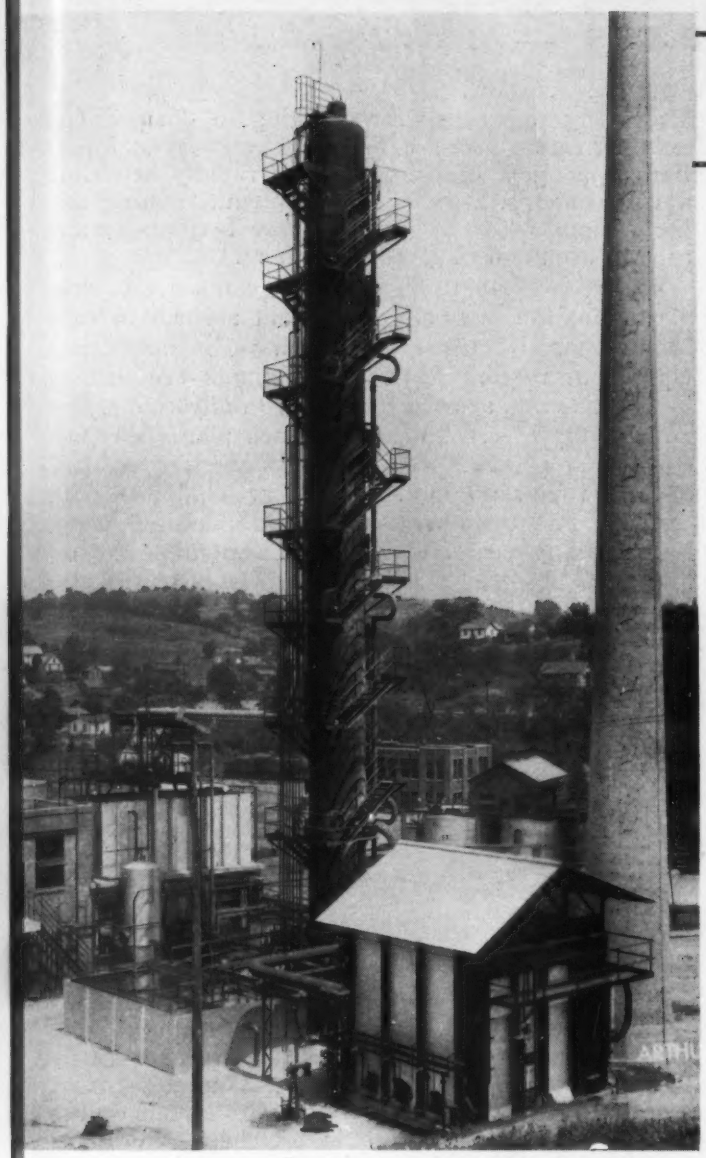
General Distillation

ALL OF the domestic refining districts and many of the foreign countries are affected in a program of construction of low pressure distillation units employed for straight distillation of crude oil, redistillation of certain fractions, redistilling solutions in lubricating oil manufacture, recovery of solvents and a variety of other distillation work. Both atmospheric and vacuum distillation units, single stage, two-stage and three-stage are employed. These tube stills replace the old shell still batteries and the earlier pipe stills. The service in distillation is usually not so severe as is the service in cracking but the corrosion of equipment is an important factor in most refining areas which necessitates frequent renewal or replacement of many equipment items.

However, much shell still capacity is still in service which must be replaced by tube stills. According to Bureau



Steam plant and pipe still, Premier Oil Refining Company, Longview, Texas.

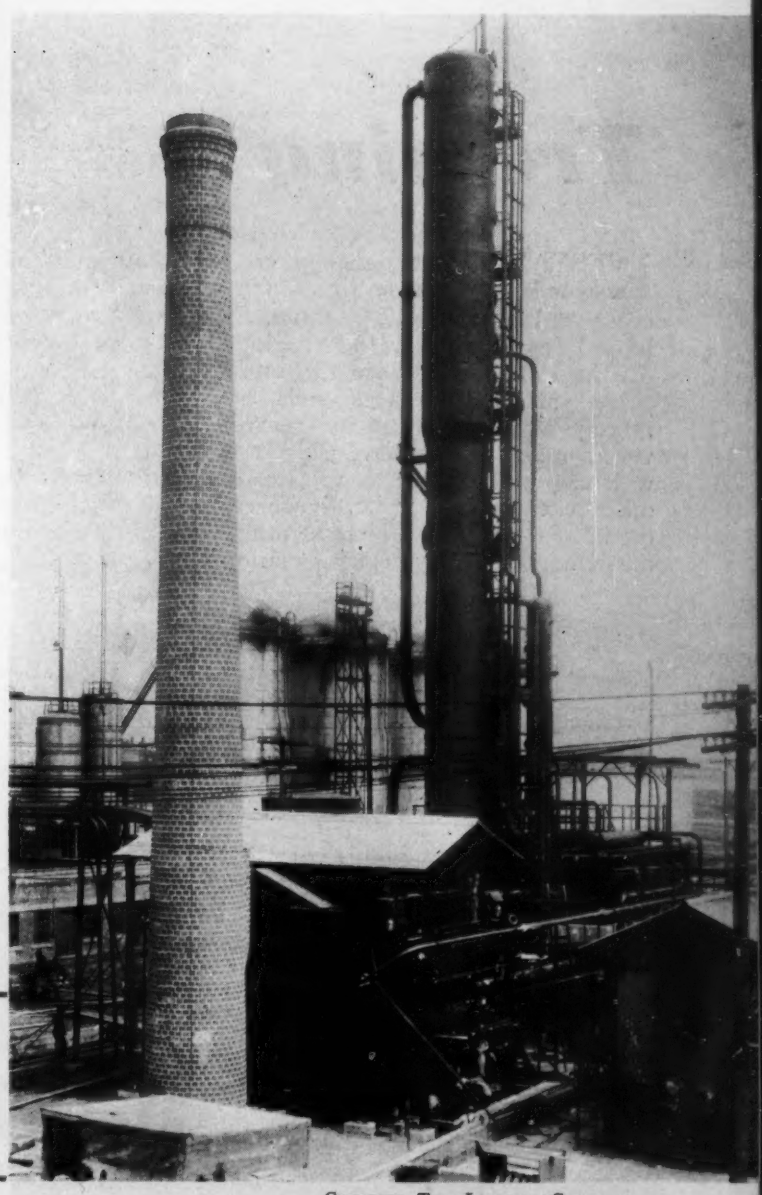


Courtesy Arthur G. McKee & Company

Typical modern crude oil distillation equipment.

of Mines Information Circular 6906, on January 1, 1936, 727 pipe stills were completed or under construction, 18 more than a year ago. Total capacity of operative pipe stills was 2,784,156 barrels and total capacity of tube stills operating on crude oil only was 2,104,840 barrels. This was equivalent to 76 percent of the total operating capacity of the pipe stills and 56 percent of the capacity of all the stills operating on crude. Therefore, the period of transition from shell stills to tube stills is not yet completed. The depression years retarded the previously rapid transition to modern practice. Currently, hardly a month passes without a few concerns announcing construction of new tube stills to replace the older obsolete shell still batteries. Of the total shell still capacity now extant, indications are that about 50 percent of it will be replaced by low pressure tube still distillation facilities, and the remaining 50 percent will probably be found in the newer combination skimming, cracking and reforming units which are applicable in many fields and with many crudes.

With every addition to the cracking departments of refineries it is necessary to install or make enlargements in the stabilization and gasoline recovery plants. When polymerization processes are employed additional stabilization systems or olefin gas concentration processes are required. These are essentially distillation processes although of the low temperature type employing usually steam or hot oil streams as the heating medium. In some plants dehydrogenation or gas cracking systems are installed to prepare charging material for the polymerization plants. Plants producing iso-octane, which is a growing



Courtesy The Lummus Company

Gulf Oil Corporation, Port Arthur, Texas, recently completed this 3600-barrel naphtha rerun unit.

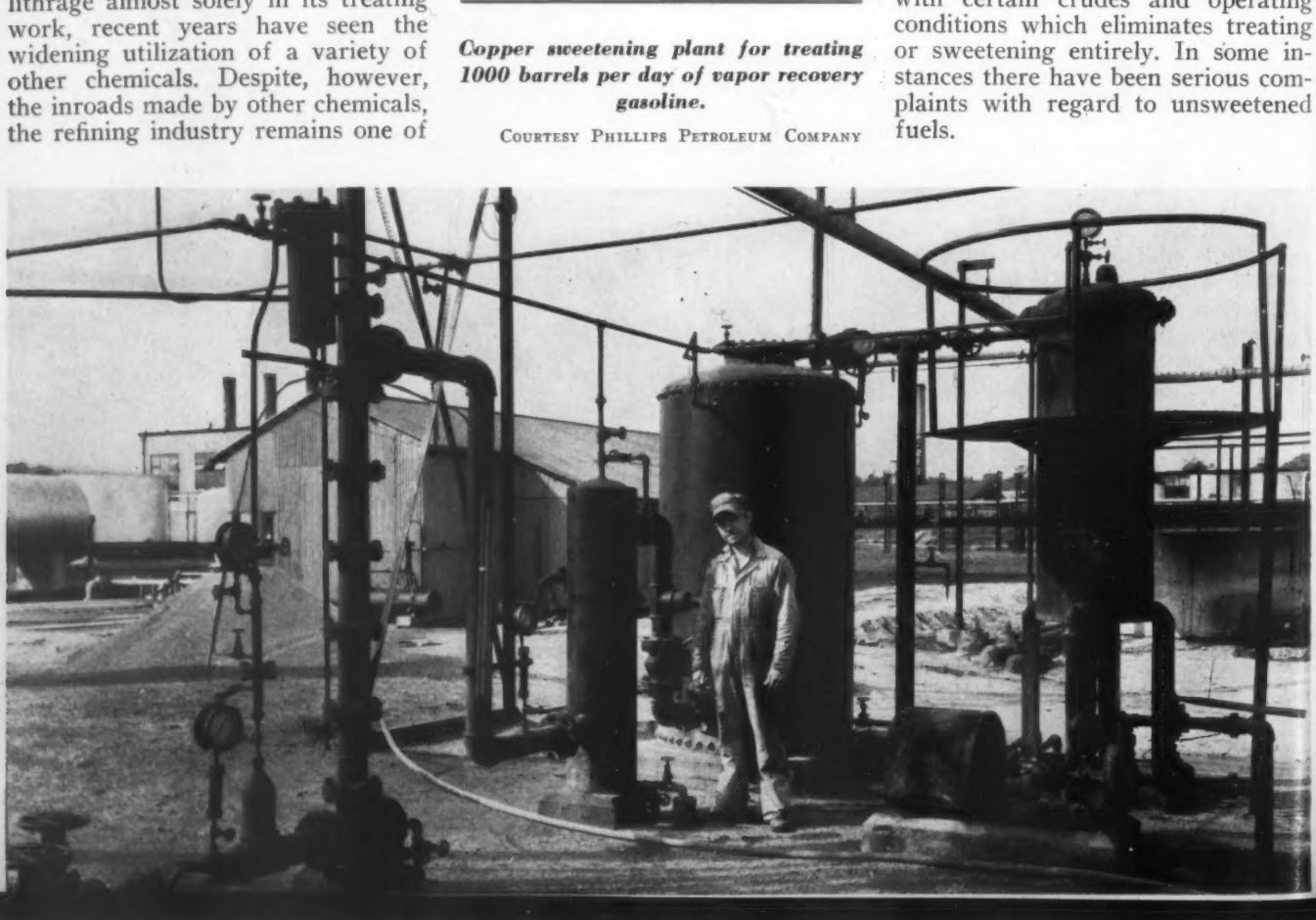
practice, require separate plants which in design and equipment needs are somewhat similar to the recovery-stabilization processes.

Since the recovery plants and stabilization plants serve a variety of purposes in addition to the recovery of gasoline from crude and light oil storage tank vapors, receiving house vapors, gases derived from cracking unit operation and other sources, their number is constantly growing. Many concerns operate separate recovery-stabilization systems for straightrun products and for cracking plant products, keeping the liquids produced from the different sources entirely isolated from one another. The stabilizer overhead gases are often the source of charge for the polymerization plants. Other stabilizers are used for isolation of butane and propane for compression into cylinders and sale as liquefied petroleum gases. When not so used the so-called "propane" cut is available for polymerization either direct in the unitary thermal type of poly plant, or after dehydrogenation for charging to the catalytic polymerization process. Thus the recovery-stabilization department of the refinery is rapidly becoming a very important factor in petroleum refining and the various types of processes are becoming more rapidly used and in greater numbers.

The recovery and stabilization plants are usually a combination of compression and absorption type natural gasoline plants, being virtually identical in equipment requirements. These plants are usually looked upon as auxiliary systems to any refinery or any battery of cracking units. Such plants are now considered absolutely essential to efficient refinery operation and no modern refinery equipped with cracking facilities operates without such equipment. Much of the earlier equipment installed in the refineries is obsolete, many of the early plants are far too small, which partly accounts for consistent construction in this field every year.

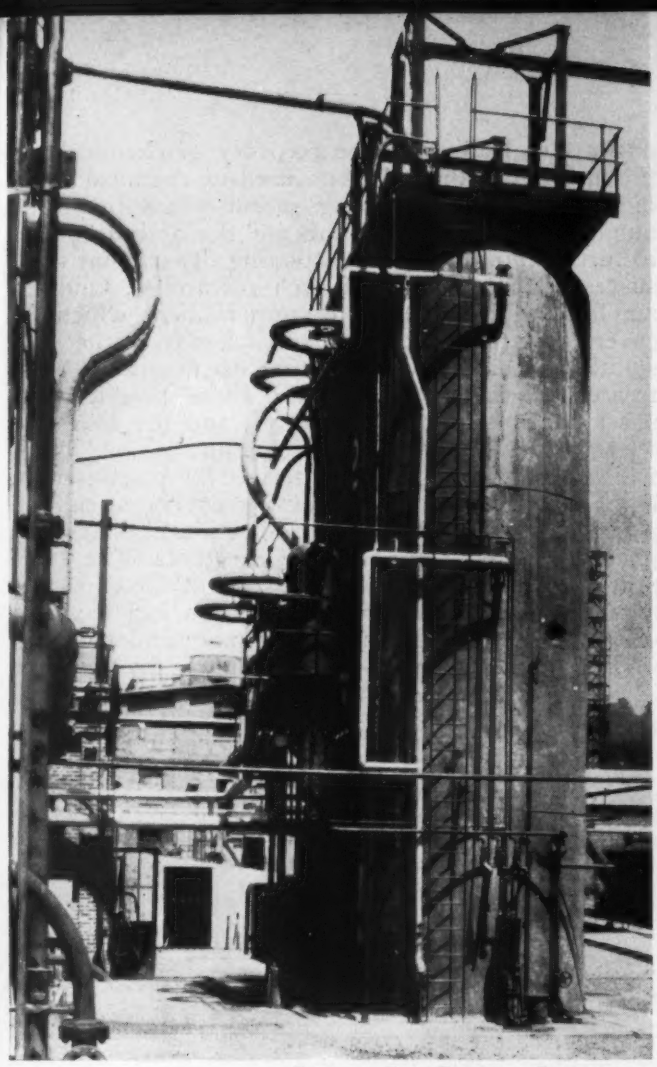
Treating

RESEARCH and development men continue the ever-lasting battle to reduce chemical treating costs and as a result a number of new processes have been developed and employed to some extent by the industry. Where the industry formerly employed sulfuric acid, caustic soda and lithrage almost solely in its treating work, recent years have seen the widening utilization of a variety of other chemicals. Despite, however, the inroads made by other chemicals, the refining industry remains one of the best customers of the acid and caustic manufacturers, and it is thought, the industry will continue such an important market for many years to come. A new development in this field is the use of inhibitors and stabilizers in certain localities and with certain crudes and operating conditions which eliminates treating or sweetening entirely. In some instances there have been serious complaints with regard to unsweetened fuels.



Copper sweetening plant for treating 1000 barrels per day of vapor recovery gasoline.

COURTESY PHILLIPS PETROLEUM COMPANY



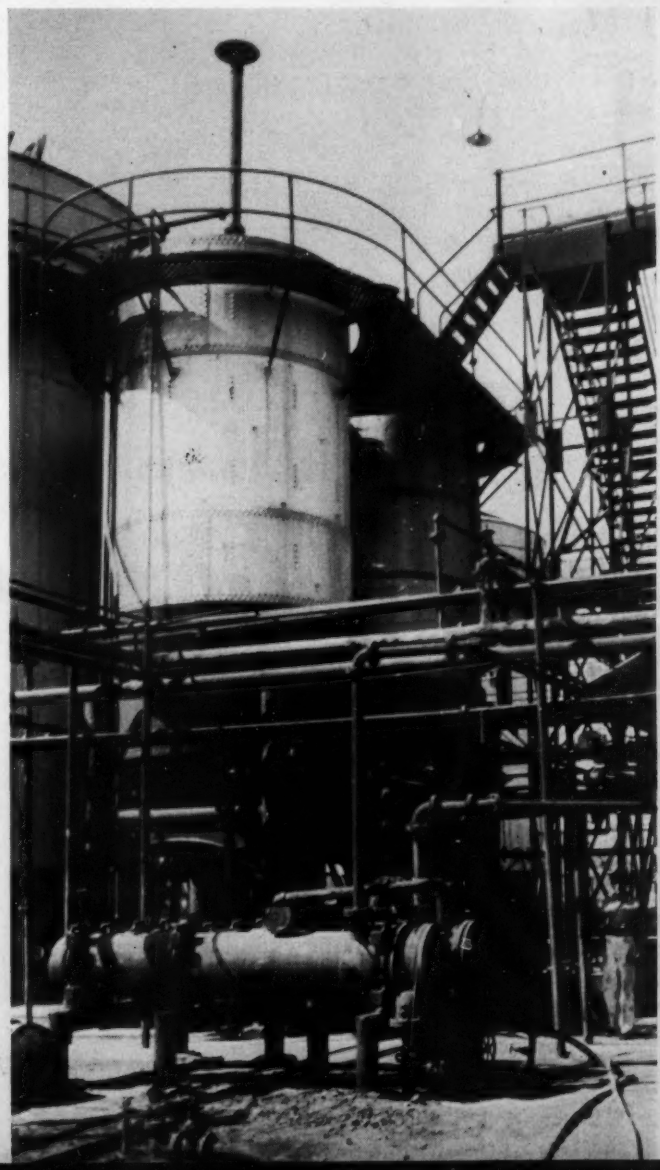
COURTESY GRAY PROCESSES CORPORATION.

Installation of clay treating process.

Processes and equipments are now available for the elimination of all such volumetric losses through emulsion. The used solutions can be centrifugally regenerated at low temperature. The oily hydrocarbons can be removed from the spent chemicals entirely. One authority estimates this lost gasoline incurred through steaming spent doctor, or air blowing, at 80 gallons for each 1000 gallons treated, and states that for the average size refinery treating around 200,000 barrels of gasoline per month, the small item amounts to around $10,000 per year. Another states that from 0.21 to 0.42 gallons are lost from each barrel treated, and these figures average about four times the amounts given above. The process of centrifugally reclaiming the gasoline, and mechanically regenerating the spent solutions, eliminates the use of steam and air blowing, thus again cutting costs and the regenerated chemicals are of much higher treating efficiency and also uncontaminated with color bearing oils. The consumption of litharge is markedly reduced. Further the fire hazards attending the older method disappear and the speed of recovery and regeneration is many times that of former steaming and air-blowing methods. It is said that the de-emulsifying and regenerating process is applicable to a wide variety of chemical solutions which may be used in treating both light and heavy distillates. For further data see "Economies in Doctor

In addition to caustic soda, sodium plumbite, acid and the hypochlorite solutions widely used for many years, and in addition to the three commercially applied clay treating processes, other processes are commanding attention. The zinc chloride process has gained recognition. The cupric chloride process is operating in a number of plants. Another process uses hydrogen chloride in the presence of a free metal such as brass. Another employs hydrated magnesium oxide, still another employs cadmium oxide. The lead sulfide process is commanding more attention. Another process involves the use of alcoholic caustic and sulfur. The list is ever widening.

One of the most confusing conditions in regard to refining is the constant effort toward better efficiency, better utilization of chemicals and their more efficient recovery, all tending to lower treating costs, while the industry on the other hand has been content for years to accept the inevitable volumetric loss of gasoline and other products without serious complaint. During the past year or so opinion has been reversed and more study is being given to recovery of naphtha and other products held in solution or in emulsion in the chemicals used for treating The fact that many refineries deliberately blow into the air from $5,000 to $10,000 and often more, in their treating department where chemicals are reclaimed is surprising and the wonder of it is that the average refiner has permitted this waste to continue for so long.

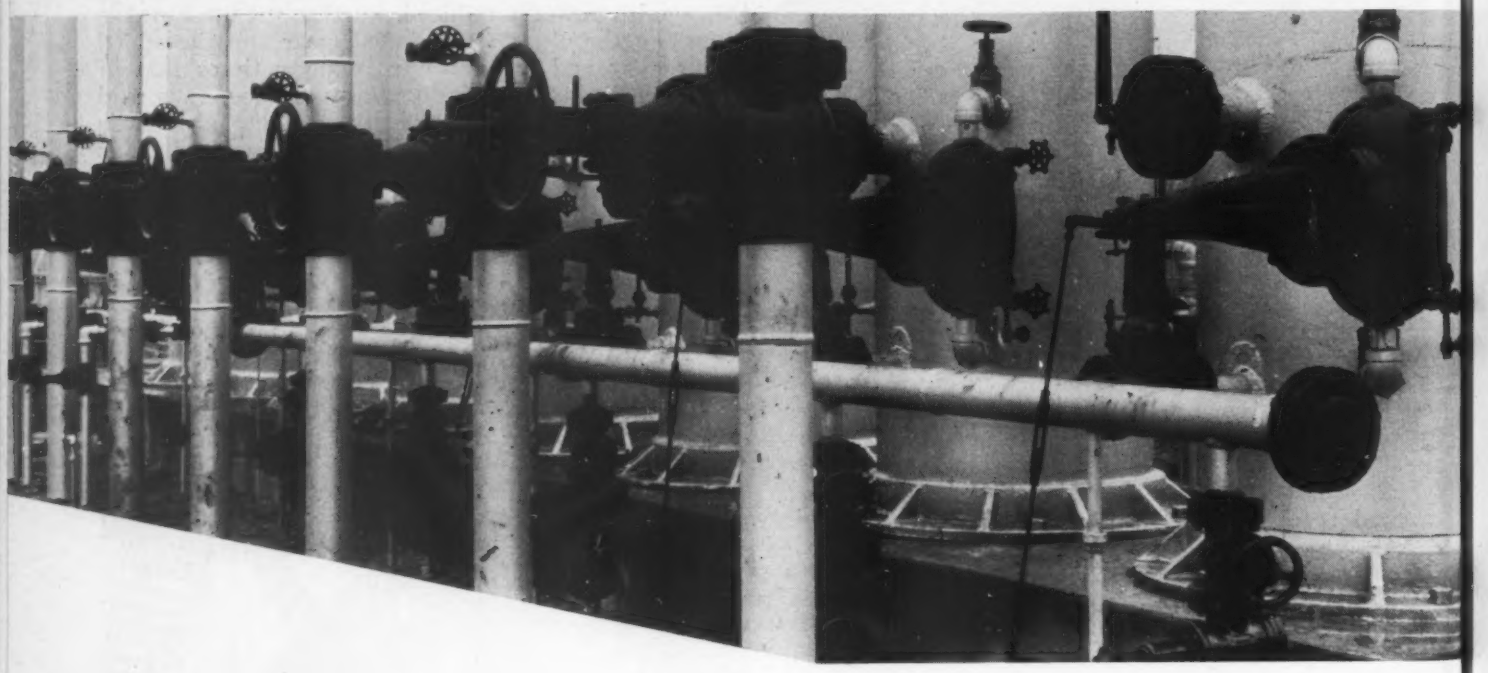


Lubricating oil chemical treating plant, Huasteca Petroleum Company, Tampico, Mexico.

Treating" REFINER, Vol. 15, No. 7, July, 1936, Page 255.

With the availability of an ever-widening assortment of new treating processes some concerns are applying several processes, using different chemicals, to their treating problems. Where one process will more efficiently handle a specific type of distillate than others, that process is used. Thus the treating departments are becoming specialized and in addition to the familiar processes are found two or perhaps more of the newly developed processes being used for low-cost treatment of individual distillates. In many plants, for example, the problem of run stability is complex, and despite duplication of equipment, it often proves best to treat all straight-run gasoline and all of the light-recovery gasoline from the straight-run side of the plant in separate treating systems, keeping these products isolated from the cracked gasoline and light gasoline recovered from cracking-unit gases. Often different chemical treatment for the products is employed.

Much work has been done and a deal of work is under way leading to the recovery of chemical by-products from the solutions used in chemical refining. The literature during recent years reports a number of such developments and this activity points to further profits from the treating department upon successful termination of such researches. One example is that of a large eastern refinery which recovers a certain amount of sulfolenes from the soda solutions which have been used to neutralize acid-treated lubricating oil stocks. These products are used in tanning solutions, soaps, and the like. Another process recovers free toxic-nitrogenous bases which are used in spray materials for plants, trees, chicken houses, etc., and also recovers a sodium phenate solution which on acidification liberates free phenols which are used as disinfectants. The same process yields soap solutions excellent for emulsifying agents for spray compounds. The fact that the chemical solutions are receiving more and more attention than formerly, indicates that the industry is realizing that therein lies a source of additional profits.

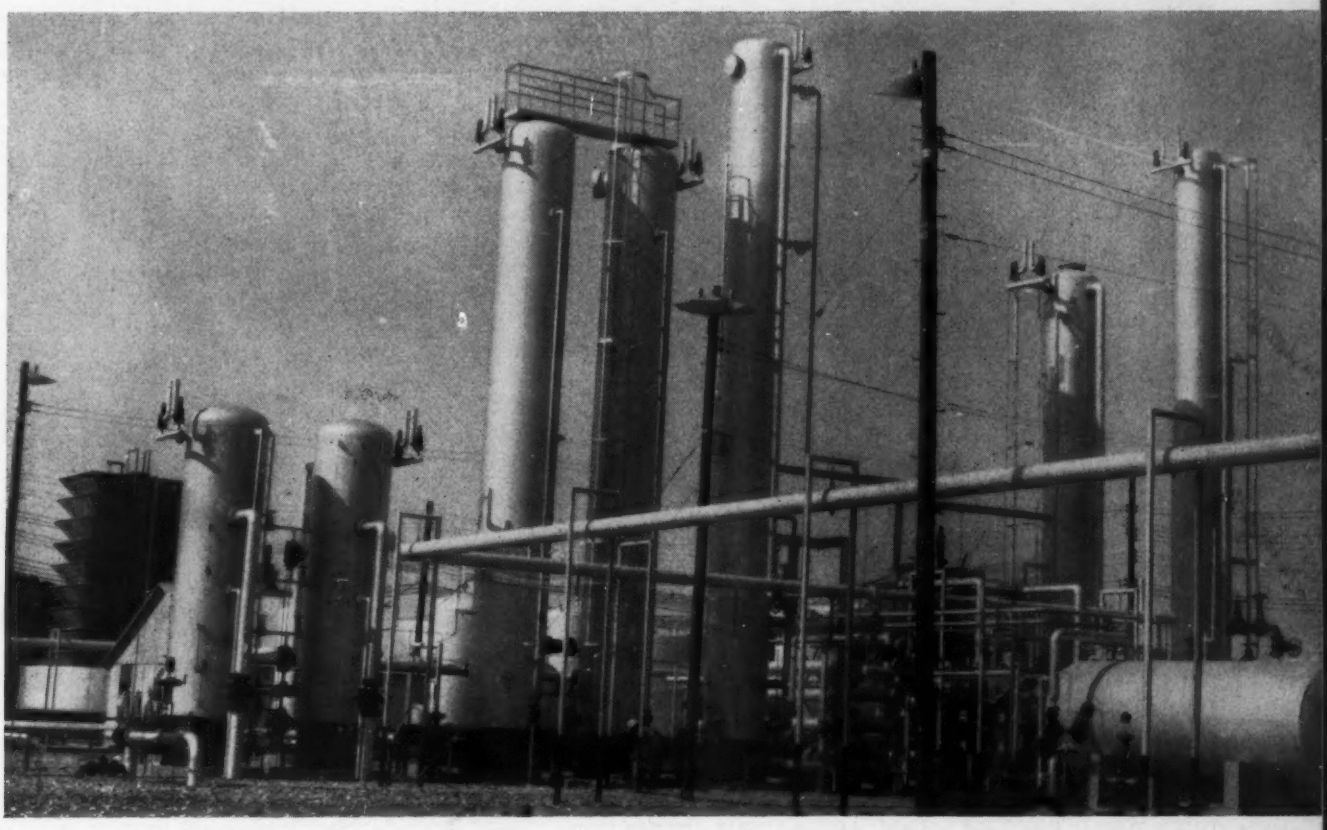


Natural Gasoline

ALONG with production and refining, natural gas and gasoline operations have made noteworthy accomplishments during the past year. Recovery from the depressing effects of governmental restrictions of less than two years ago, and the further development of producing fields have done much to stimulate construction and modernization programs in which the gasoline manufacturer's desire to keep pace with the rest of the industry has been clearly reflected. Engineering developments have also served to focus attention on the new and better ways of doing things. Next year's advancements undoubtedly will give consideration to polymerization, air-conditioned compressor rooms in dust-ladden districts, the dehydration of dry gases, pressure-loaded regulators, and a host of improvements which will permit doing old jobs in new ways. The technical side of natural gas and gasoline always receives its quota of attention and this year has been particularly fruitful in bringing out new and interesting discussions which are helpful in reducing design, construction, and operating problems to a mathematical basis.

Considering the gasoline industry as a whole, the past year has witnessed the continued displacement of the small plant and the building of large, well-equipped units. Economic conditions are still far

from what could be wished for, but operations during 1936 were of a calibre which bears ample testimony to the success of the gasoline industry's struggle from 1933 when national production hit a ten-year low of 1,420,000,000 gallons, to a figure, which for 1936, will probably be close to 1,750,000,000 gallons. This would indicate an estimated increase of 23 percent over 1933, and 8 percent over 1935.



Combination crude oil stabilization and natural gasoline plant at Tepetate, Louisiana, operated by Continental Oil Company.

Any increase in natural gasoline production is, of course, based on an equivalent increase in the output of natural gas. The national production last year of 1,875,000,000,000 cubic feet represents the greatest volume produced since 1930. For 1936, production should be near 1,975,000,000,000 cubic feet.

Continued growth of the East Texas field has given Texas the most material gain in new gasoline plants of any of the major producing states. Oklahoma and California, however, have been mindful of the need for expansion and have been carrying on active programs. The activities within these latter states, although second to Texas during the past year, are important and have contributed substantially to post-depression advancement. Activity in Louisiana has been marked and the steady increase in the volume of natural gasoline produced in this state is indicative of successful field developments. California still produced the largest volume of natural during the year, with Texas second and Oklahoma third. By districts the Texas Panhandle field is still the nation's leading natural gasoline producer. Kettleman Hills, California, rates second place, although at certain periods of the year East Texas and Oklahoma City fields came close. If East Texas developments continue as actively next year Kettleman Hills will probably drop to third place.

Construction

FOR SHEER speed and magnitude of development nothing has attracted attention like the Rodessa field in Louisiana. In an incredibly short time about 400 wells have been completed, and over 300 operators are still actively drilling as this is written. Moreover, in a field where not one dry hole has been drilled where the 6,000-foot zone has been reached, gasoline plant developments should command more than passing interest. Prominent among the new gasoline plants are Coltexo Corporation's 50,000,000-cubic-foot unit; Eastern Texas Production Company's 10,000,000-cubic-foot unit; and Glenrose Gasoline Company's 20,000,000-cubic-foot plant

Warren Petroleum Company is also participating in the development of this district with a compression type plant; as well as the Tide Water Oil Company (formerly Pelican Oil & Gasoline Company) with a 50,000-gallon a day unit; and Rodesa Gaso-

line Company, two miles west of Ida, with a 30,000-gallon unit.

Cass-Liberty Gasoline Company, Dallas, Texas, is erecting a well-pressure absorption-type natural gasoline plant in the Cass County, Texas, section of the Rodessa field. Capacity is to be 20,000,000 cubic feet per day. Phillips Petroleum Company joins the Rodessa gasoline manufacturers through erection of its 50,000,000-cubic-foot absorption plant of well-pressure type, which is also located in Cass County.

Progress in Oklahoma is reflected by such installations as Carter Oil Company's plant in the Fitts pool; Del Rey Production Company's 30,000,000-cubic-foot absorption unit in the Britton area; Smith Brothers Refining Company's 50,000,000-cubic-foot installation in the Sayre field; and Magnolia Petroleum Company's 16,000-gallon plant in the same district. In the Burbank field, Skelly Oil Company's Lyman plant was modernized by dismantling the absorption system and converting it into a vapor rectification unit. In the new layout the rectifying column operates at a pressure and temperature which retains the maximum amount of propane and butanes, as well as the heavier fractions. Other columns have been erected for making special cuts.

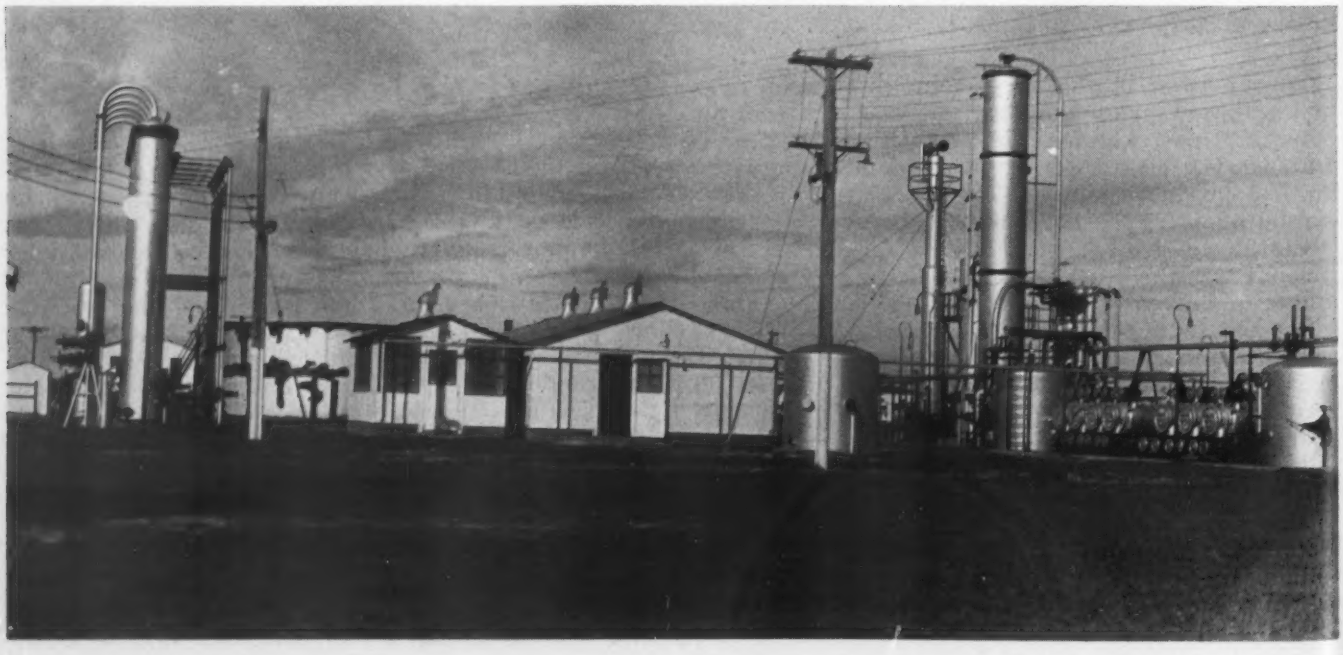
Signalizing the first natural gasoline plant development in North Texas for many years is Deep Oil Development Company's 3,000,000-cubic-foot compression-type plant in the Chalk Hill field. Noteworthy changes in East Texas field are the increased compressor capacity in Humble Oil & Refining Company's installation, and construction, by Sinclair Prairie Oil Company of a new 12,000,000-cubic-foot absorption unit in the Joiner area. In the Grand Falls district Standard Oil Company of Texas built a 20,000,000-cubic-foot absorption plant. Other installations which have increased Texas' daily production capacity by fully 165,000 gallons are represented by Empire Oil & Refining Company's unit in the Cowden field, General American Oil Corporation's plant in Rusk County, Gulf Oil Corporation's plant in Ward County, Magnolia Petroleum Company and the Smith Brothers' plants in Winkler County, Manhattan Gasoline Company's unit in San Patricio County and Marr Gasoline Company's plant southwest of Henderson.

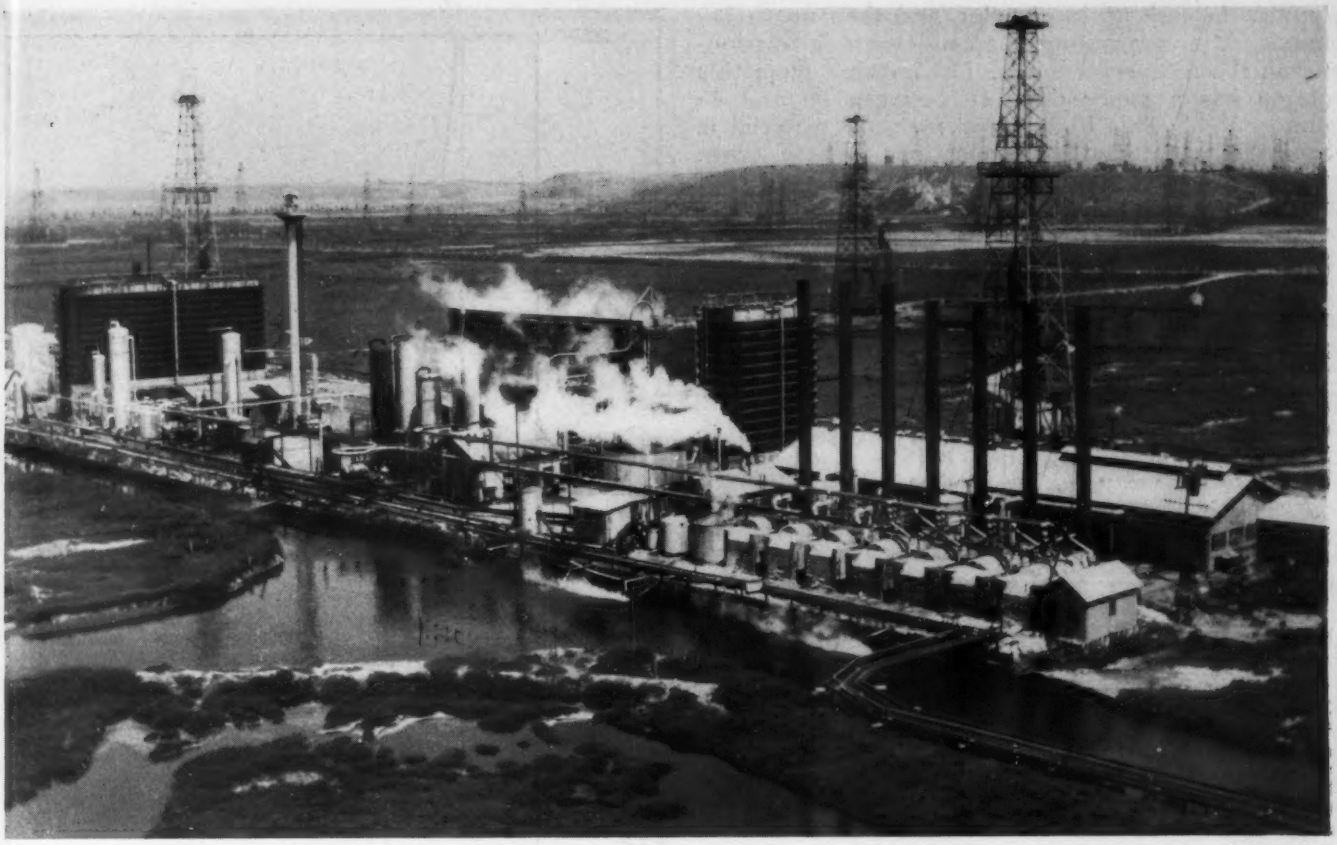
Southern Minerals Corporation, an affiliate of Southern Alkali Corporation, Corpus Christi, announced plans late last month for construction of a low-pressure absorption-type gasoline plant in the Saxet field, Nueces County, with capacity of 25,000,000 cubic feet per day.

While the lack of any outstanding field development has held California gasoline operations somewhat in check, the Pacific Coast industry can point to two interesting installations during the past year: Shell Oil Company's absorption unit which is treating the gas from the Section Ten field between Bakersfield and Taft; and The Texas Company's Plant No. 14 in the Montebello field extension which is treating the gas formerly handled by its old Plant 11 in the same district. Shell Oil Company's plant is of the latest design and was built at a cost of $160,000 to handle a gas volume of 16,000,000 cubic feet daily. It is of the absorption type. The Texas Company plant has a maximum daily gas capacity of 20,000,000 cubic feet. At present it is treating the gas produced by approximately 39 wells and has a daily gasoline production of around 10,000 gallons.

New Mexico, Michigan and Kansas also took their place in the year's gasoline development when Phillips Petroleum Company built a one-unit plant in the Eunice field, and O. H. Grimes Company constructed an absorption unit in Michigan's Yost-Jasper field. Near Liberal, Kansas, Panhandle Eastern Pipe Line Company has built a combination absorption and gas dehydration plant. The installation has

United Gas Public Service Company gasoline plant at Refugio, Texas.





Del Rey Oil & Gas Company's gasoline plant in the Del Rey, California, field. Because of marshy ground all plants in this field are built on dirt fills. Piling must be sunk for any equipment of considerable weight.

a capacity of 135,000,000 cubic feet per day with room for expansion to a future daily capacity of 200,000,000 cubic feet. Operating pressures are close to 450 pounds and the dehydration of the dry gas is carried out with calcium chloride brine.

Since the discovery a short while ago that moisture precipitated in natural gas at high pressures causes the formation of solid compounds known as hydrocarbon "hydrates," the question of reducing the dew point of high-pressure gas has received special engineering attention. One of the successful ways of demoisturizing natural gas is through application of calcium chloride brine in a countercurrent scrubbing system. In describing the system used by Panhandle Eastern Pipe Line Company, H. N. Wade (*Gas, September, 1936*) states, "The contact between the gas and the calcium chloride is accomplished in the top section of the absorbers. Bubble-cap plates of conventional design are used for this contact. A special scrubbing section is interposed between the top of the oil-absorbing section in each absorber and the brine contact plates; a similar scrubber is installed above the brine contact plates to remove from the outgoing gas all traces of entrained brine droplets. The wet gas entering the base of the combination absorbers is thus treated for extraction of gasoline vapor, scrubbed, dehydrated, again scrubbed, and finally delivered from the top of the absorbers dry and free of all entrained liquids, ready for delivery to the transmission line." The water taken up by the brine is removed in an evaporator and the brine concentration kept constant by the use of automatic controls.

Consideration is being given the application of glycerine and diethylene glycol instead of calcium chloride brine. In the case of these chemicals, the same as with calcium chloride, contact between gas and the dehydrator is brought about through countercurrent flow. The dehydrating solution is then heated to release the moisture and then recirculated back through the absorber.

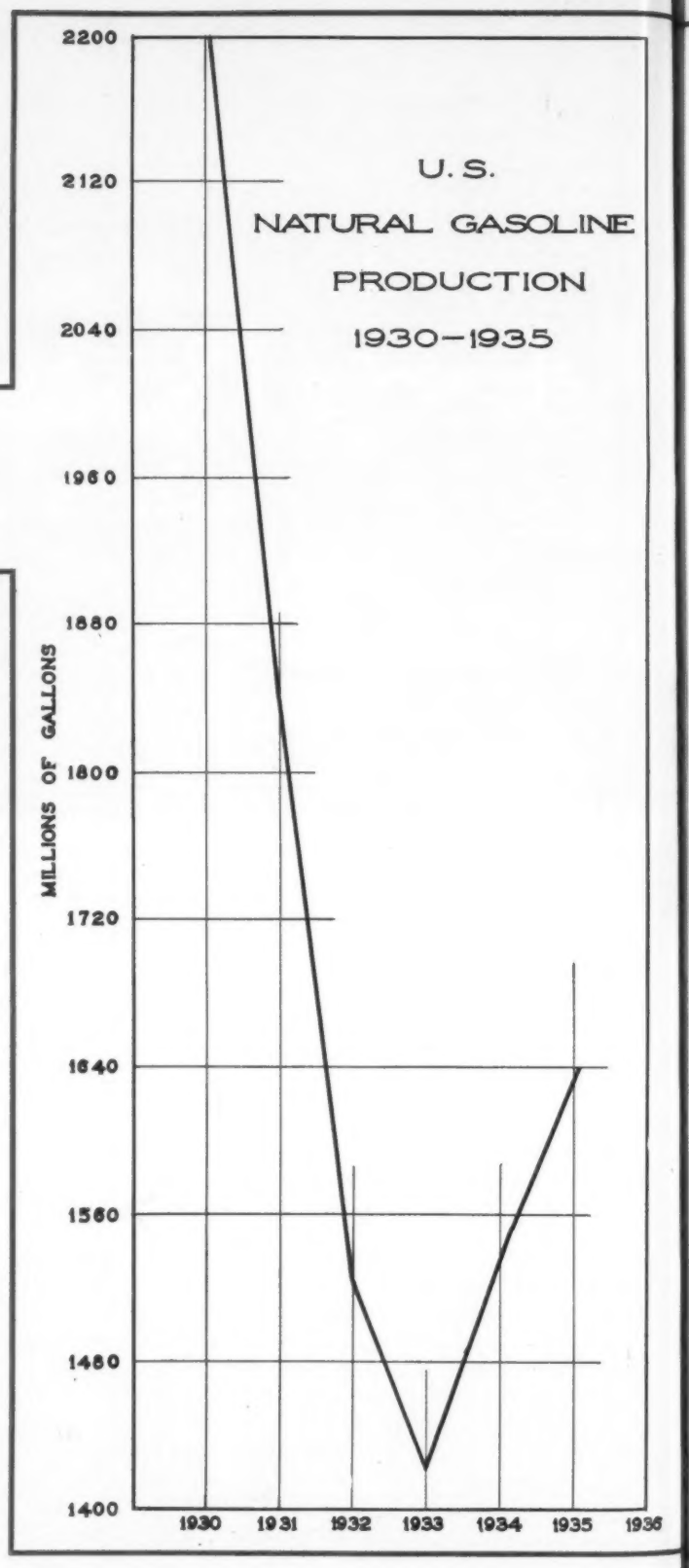
Engineering and Design

IN DISTRICTS where wet gas is high in propane and butanes and poor windage and a low water supply make cooling a problem, the last five years have witnessed the steady growth of vapor rectification. And this year, as far as the Mid-Continent is concerned, saw no abatement in this trend. In principle the vapor rectification cycle consists of the two-stage compression and intercooling of wet gas and the subsequent injection of the resulting liquid directly into a high-pressure rectifier where the regenerated vapors pass upward through trays countercurrent to the descending reflux. The overhead from the column goes to an accumulator and then to the fuel line. The bottoms are then sent to a stabilizer and there reduced to sales specifications. One interesting case reported is that of an 11,000,000 cubic-foot plant where 11 two-stage compressors boost the gas to a first stage pressure of 40

pounds, through an intercooler, and then up to 275 pounds. After precooling, the condensate is fractionated in the recovery column. The bottoms from this column has a vapor pressure between 30 and 45 pounds, Reid. This high vapor pressure material is then stabilized to sales specifications. Where a wet gas has a composition which permits this type of treatment the claim is made that the percentage of pentanes and heavier fractions recovered is higher than that recovered by oil absorption.

While vapor rectification is receiving increased attention in the Mid-Continent, California continues to use the conventional oil-absorption system. During the year, in addition to the new plants built by Shell Oil Company and The Texas Company, Union Oil Company completely rebuilt its Dominguez absorption plant. One innovation at this plant, while not new to the Mid-Continent, has attracted considerable discussion in the west. It concerns a direct-fired fat oil preheater. This is probably the only installation of its kind in a Pacific Coast gasoline plant and the outcome of its application will be watched with interest.

Economic conditions are still far from what could be wished, but operations during 1936 bear ample testimony to the success of the gasoline industry's struggle from 1933 when national production hit a ten-year low of 1,420,000,000 gallons, to a figure, which for this year, will probably be close to 1,750,000,000 gallons.

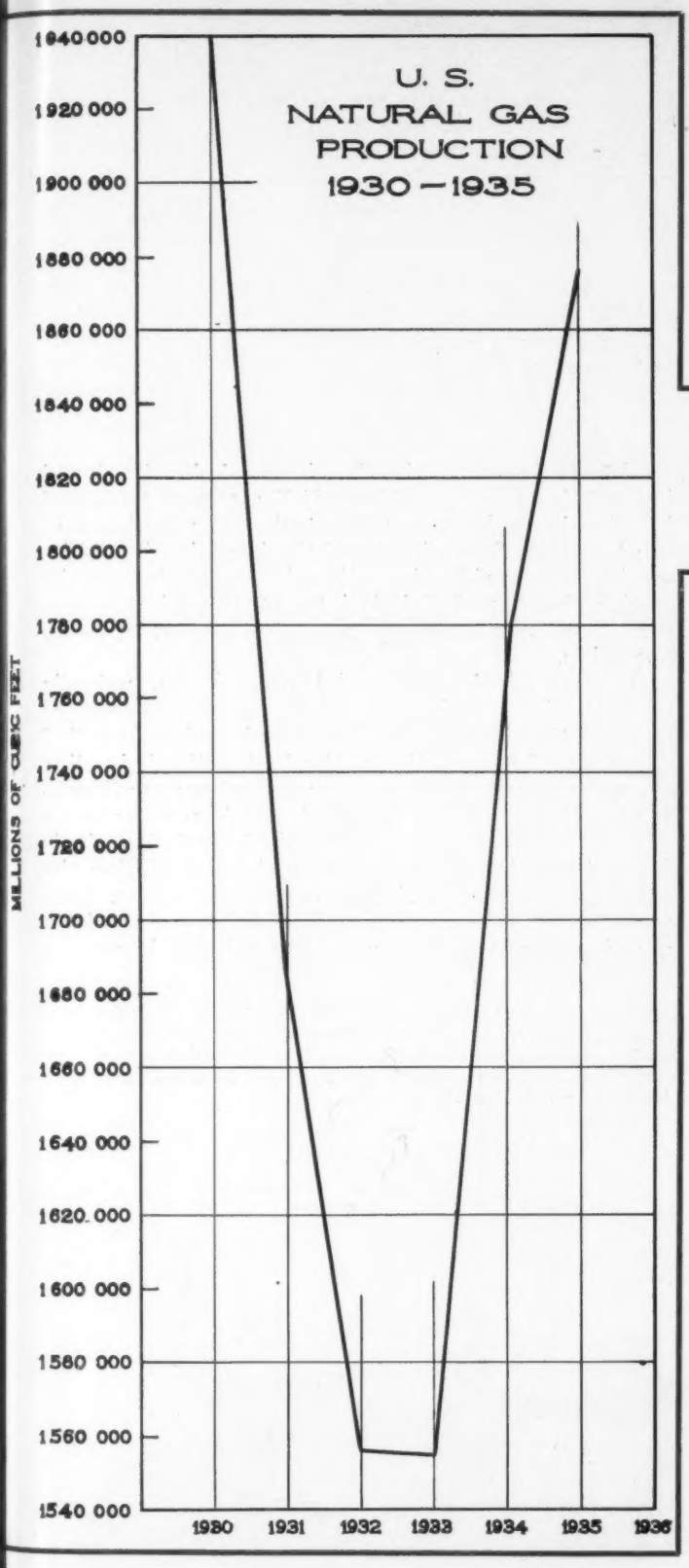


The treating of sour gas and the sweetening of sour gasoline is nothing new to many gasoline manufacturers, but it is new to those in California's Del Ray field who have been faced with the unusual sulphur properties of the gas in this district. To this extent the efforts made by one operator may be of interest. At Del Ray Oil & Gas Company's plant the incoming wet gas has a hydrogen sulphide content which varies from a trace to as high as 60 grains per hundred cubic feet. While this sulphur content is not excessive when compared to that found in other districts, regulations imposed by the California Railroad Commission on the sulphur content of dry gas makes the problem of treating it of equal magnitude. The system used consists of treating the stabilized gasoline with calcium hypochlorite. With the gasoline containing 15 to 30 milligrams of sulphur bodies per liter it has been found that a solution containing 15 percent by weight of hypochlorite is the best. The sour gasoline is passed through an upflow wash tank containing the solution and then on to storage. Sulphur removal from the dry gas is carried out by passing it over wood shavings impregnated with iron oxide, where the combined sulphur is oxidized to iron sulphide and water. A small amount of free air (about 3 percent) is introduced along with the gas to be treated. The air serves to oxidize some of the iron sulphide back to iron oxide and renders the process practically continuous.

DESIGN

In the field of design, a simplified system of calculations for absorbers has been discussed (REFINER, Vol. 15, No. 1, Jan. 1936), which permits a choice of coordinates for setting up a Lewis operating line diagram in terms of units of measurement commonly used around the gasoline plant. A basis of 1000 cubic feet of wet gas measured at 60° F. and atmospheric pressure has been chosen. The operating line for butane is given by the equation $B_v = B_o + B_d$, which means that the volume of butane rising to any plate is equal to the volume of butane leaving in the dry gas. An equation for calculating the equilibrium line is also shown, as well as a method of estimating fat oil temperatures.

A new type of absorber and fractionator tray has been developed. It consists of a 7-foot tray drilled



with 5/32-inch holes on 1-inch centers with hexagonal drilling. Twelve overflow tubes extend 5½ inches above the plates and are surmounted by collector pans 12 inches in diameter and 1½ inches deep. Into each hole in the plate is inserted a conical head, split-shank rivet. The head of the rivet is ⅜-inch in diameter with a 3/16-inch shank. Each rivet is free to move. The passage of gas up through the tray lifts the rivets to a height proportional to the gas through-put. The claim is made that oil and gas contact is more intimate and is brought about without channeling. (REFINER, Vol. 15, No. 4, April, 1936).

A novel design for a gasoline plant distillation system was developed for a Mid-West unit. The distillation system is divided into three separate units: a flash tank, a stripper, and a fractionator. Hot fat oil from the preheater is set directly to the flash tank. The overhead vapors from the flash tank are sent directly to the upper section of the fractionator, and the liquid bottoms to the upper section of the stripper. Overhead from the stripper is put through cooling coils and the condensate and uncondensed vapors

Successful wildcatting and the further development of producing fields did much to stimulate output of natural gas during 1936. Production in 1935 was 1,875,000,000,000 cubic feet and represents the greatest volume since 1930. For 1936 national production should be near 1,975,000,000,000 cubic feet.

sent to a reflux tank. Vapors from this reflux tank, together with those from the water trap, are then sent through a recompressor. Bottoms from the reflux tank are pumped to the upper portion of the fractionator.

The stripper bottoms are then sent back to the lean oil system along with heavy ends from the fractionator. This is because the overhead from the stripper consists of all of the gasoline contained in the fat oil along with some residual oil fractions. Unrectified condensate is used for fractionator reflux. The function of the fractionator is for end-point control. The product distilled goes overhead through a cooling system to a water trap. Vapors from the water traps are mingled with those from the reflux tanks and sent through the recompressor on to the upper portion of the rectifier. The liquid content of the water trap is pumped directly to the rectifier, and then as finished product to the storage tanks.

Technical Development

A PROCEDURE has been developed for determining the dust content in gas flowing through transmission lines. (Gas, July, 1936). Paper thimbles are used in connection with a sampling device. A measured portion of gas is passed through the thimble sampler to collect any solid material which may be present. The material usually extracted consists of moisture, dust and oily matter. The oily matter is removed by solvent extraction, and the dust reduced to an oil-free basis. After reducing the dust obtained to a constant weight, a microscopic examination is made for particle size and particle characteristics determination. In one instance the dust content in a transmission line was found to vary from 6 pounds to around 600 pounds per million cubic feet.

It has been shown that a desirable improvement in the technique of conducting calorimeter determination on natural gas consists of the pre-humidification of the air used for combustion. An apparatus

has been designed to carry out this new procedure. (Gas, August, 1936.)

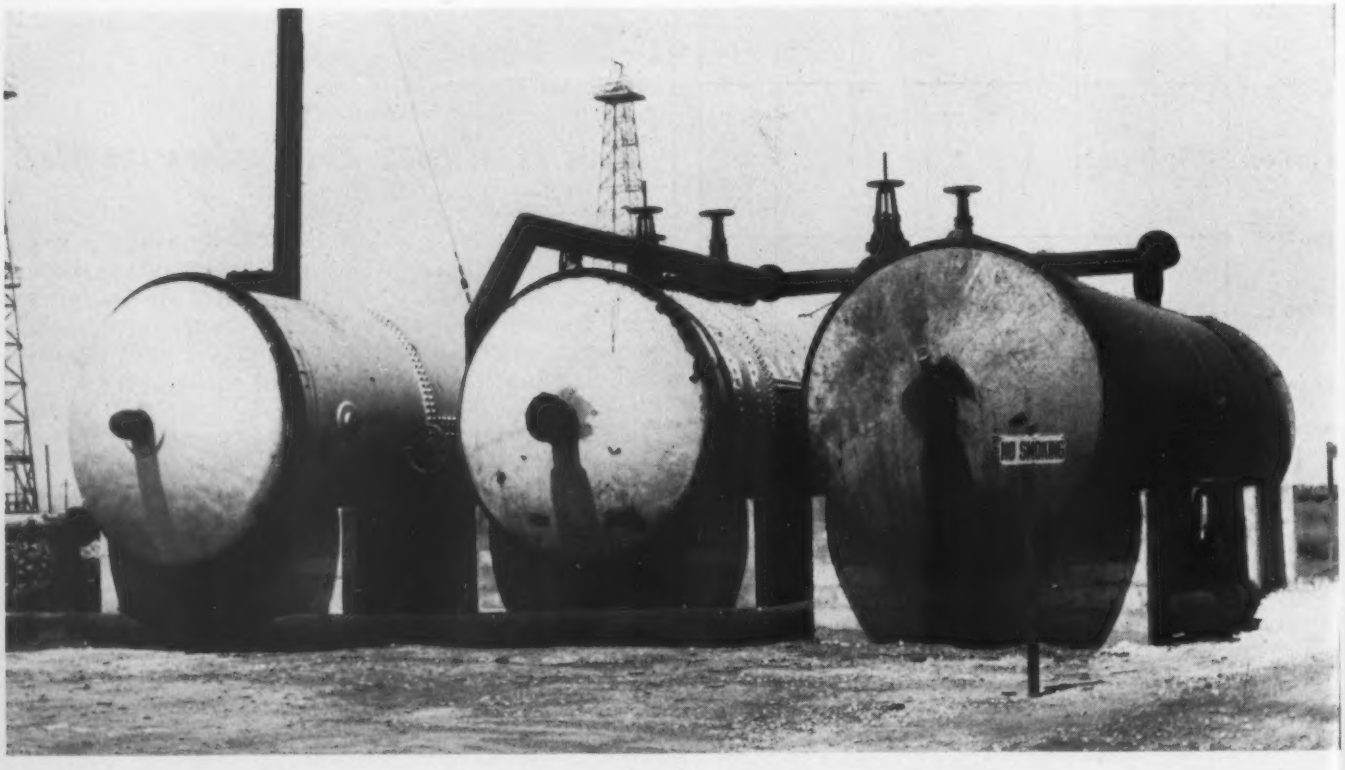
Continuing joint experiments which were reported last year Dr. Drury of the University of Southern California has published results which give added confirmation to those previously published, that natural gas, even in concentrations of 25 percent and 30 percent by volume, has no dangerous effect on the human body. High concentrations of natural gas fractions have been shown to have an anesthetic effect, but this effect has not been shown to be detrimental to health.—(Gas, September, 1936.)

The phenomena of combustion in natural gas engines has been reviewed. It is pointed out that in all engine installations, regardless of fuel cost, there is one important factor in favor of proper adjustment. An engine adjusted to burn its fuel efficiently usually has a lower maintenance and replacement cost rate. For example, the combustion of methane with 10 percent excess air would result in an engine using such a mixture to develop less power than one using a correct mixture. The prevention of the escape of unburned fuel directly to the exhaust is a problem in two-stroke cycle gas engines. By admitting fuel to the power cylinder directly after the ports are covered by the piston, waste of fuel to the exhaust is eliminated. Waste to the exhaust may be eliminated by proper design of the exhaust pipe system.

The year 1936 has witnessed the continued application of cathodic protection for the prevention of corrosion in pipe lines. Its introduction four years ago was looked upon by many with scepticism, but the outstanding benefits obtained by its use has convinced the incredulous and has definitely established it as an indispensable part of good pipe line service equipment in those districts which have proved to contain highly-corrosive soil. The availability of transmitted electric power which, in the early stages of cathodic protection, limited the application of this type of treatment to those areas which were serviced by transmission lines, has been greatly done away with by the introduction of portable generating units. Wind-driven propeller generator units, and more recently, the small gas engine-driven units, have enabled the application of cathodic protection at any place on the line, whether it be accessible to line power or not. This type of protection against corrosion has been wholly developed in Gulf Coast fields and in Gulf Coast areas traversed by pipe lines. However, the technical soundness of the treatment has stimulated the investigation of its merits in other districts. Certain companies on the Pacific Coast are definitely interested in this arrangement, and one company now has several units in operation.

Because of the successful use of the cathodic method of protecting pipe lines from corrosion in the Mid-Continent, a California Utility has installed 22 stations for protecting a 64-mile length of pipe line through a particularly corrosive section near Southern California. In a report describing experiences over the past 4 years with this installation, it is pointed out that for the average size installation the copper oxide rectifier is the most satisfactory. Vacuum-type rectifiers have too short a life and too high a replacement cost to be entirely suitable in service

Treaters for the removal of hydrogen sulphide from the dry gas at the Del Rey Oil & Gas Company's plant in the Del Rey, California, field. Wood shavings impregnated with iron oxide constitute the chemical used. The treater shells are 7 feet in diameter and 28 feet long. Each contains three horizontal shelves for holding the treated shavings. The shells are piped for operation either in series or in parallel. The sour gas enters at the top of each treater and leaves at the bottom.



24 hours a day, every day of the year. Mercury arc rectifiers were also found inefficient when operated at small loads. The ruggedness and inexpensiveness of the copper oxide rectifier has made it very attractive in the installations in which it is now in use. Recent improvements in transformer design have raised its output efficiency to between 55 percent and 60 percent.

A new and interesting development which the year has brought is that of the air conditioning of compressor rooms in districts where dust storms are encountered. (Oil & Gas Journal, Sept. 24, 1936.) One pipe line company which operates in Kansas is reported to be constructing a compressor room which will be completely air conditioned. Washed air will be supplied to the engine intakes after having passed through a water spray which cools it, followed by the removal of excess moisture by mist extractors placed in the system between each washer and blower. In the case reported, the blower is driven by a 3-horsepower motor and is capable of delivering 10,000 cubic feet of washed air per minute. One air-conditioning unit is supplied for each engine. During summer operation some of the pre-cooled air is circulated around the exhaust manifold to act as a cooling agent for the exhaust muffler itself.

RUPTURES IN PIPES

Leaks caused by ruptured pipes or pipe fittings have been shown to be more liable to occur during the time following installation and the end of the first rainy season. As the ground settles around the pipe, and initial strains are relieved, the hazard lessens. Another factor contributing to the permanency of large transmission lines has been shown to be the use of welding. These heat methods of making pipe joints have eliminated the use of flexible and threaded couplings. Experience has brought out that the use of bell joints, along with manufactured bends, have also reduced the hazard of rupture at points of considerable strain. The relationship of pipe wrappings to the corrosiveness of soil has brought about such substantial improvement in the protection of pipe lines from corrosion that some engineers are now insisting that entire pipe lines be insulated, and the result of soil surveys used only in deciding the thickness of the wrappings to be applied.

In carrying out one system of pipe line maintenance, it is customary in sections where active corrosion is suspected to drill test holes down to the buried pipes at frequent intervals. Field reports are made out for each of the test holes made, and which describe the condition of the pipe examined. These reports are kept on file and referred to at regular intervals, when it may be desired to reopen certain sections of the line and note the progress of corrosion. Some concerns conduct electrolysis surveys after each rainy season, in order to determine the locations of positive areas.

A company operating a 20-inch gas transmission line from the Long Lake and Cayuga fields in Anderson County to a point near Dallas, Texas, has developed a new method for insuring longer life for couplings. The procedure for carrying out the protective treatment is simple and employs a wooden shield fitted snugly around the coupling and then filled with coal tar pitch.

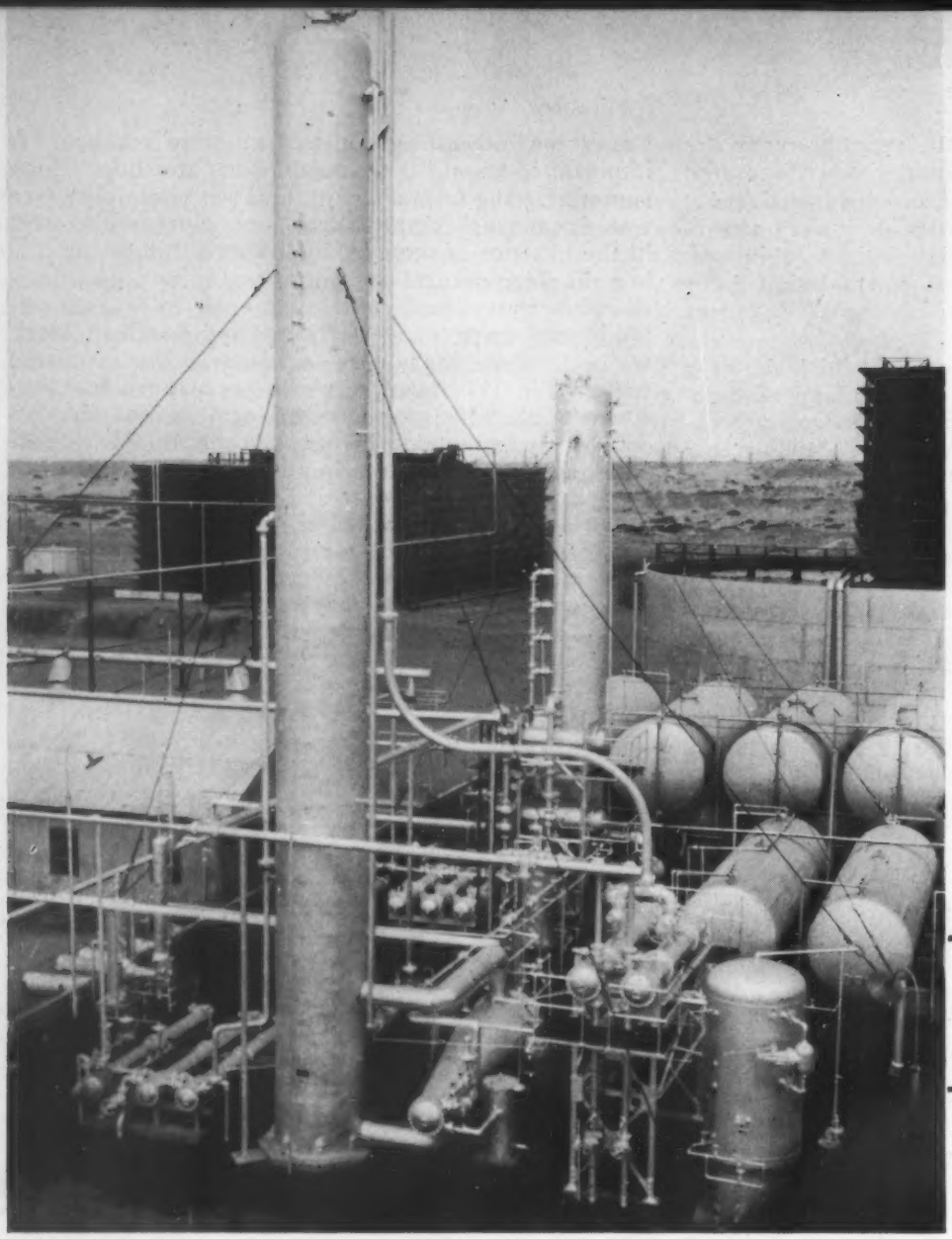
In a study made to determine the internal corrosive effect of various substances in flowing natural gas, some interesting conclusions were reached. Of importance among these conclusions are those which summarize the following: natural gas containing free water at normal temperatures is not corrosive to steel in the absence of oxygen, hydrogen sulphide, or carbon dioxide; natural gas considerably under-saturated with water, but containing both hydrogen sulphide and oxygen, is not corrosive to clean steel, while the same gas is very corrosive if over-saturated with water. Hydrogen sulphide has a much less corrosive effect when present in natural gas than has an equivalent amount of oxygen. Carbon dioxide in natural gas is of much less importance than either hydrogen sulphide or oxygen. Probably of greatest importance is the conclusion, "The products of corrosion removed from a pipe line are, of themselves, very corrosive in the presence of liquid water and a trace of oxygen, and may even become somewhat corrosive at below saturation."

Gas Polymerization

AS one commentator has put it, the latter part of 1935 and most of 1936 has been a "gas year" because of the attention the oil industry has given the advent of commercial processes for the polymerization of gases. But because of its newness there has been little time to evaluate the dollars-and-cents significance of this new factor. Furthermore, not enough has been done yet which would permit an accurate or informative observation as to its full economic significance. It is evident that there are two sources of raw material for this process; the unsaturated gases made by refining processes, and the saturated gases extracted by the gasoline manufacturer. But of principal interest to this discussion is a conjecture or two as to where the gasoline manufacturer may fit in, and what he may do.

At the outset of such an appraisal, it appears that what the natural gasoline manufacturer does cannot hinge alone on what the refiner does. The raw materials each use are different, and, most important of all, the natural gasoline manufacturer is geared to a somewhat different type of economic setup. The refiner generates the unsaturated gases he uses as part of a process wherein a liquid raw material (oil) is used. Moreover, these gases are incidental to the production of the principal products. On the other hand, the gasoline manufacturer has the opportunity of considering liquefied petroleum gas as an outlet for his surplus propane and butanes—and in certain respects it is thought this outlet, in spite of well-known difficulties, can still remain more attractive to many operators than polymerization for some time to come.

The gasoline manufacturer can build a good liquefied petroleum gas column together with lines, tankage, etc., for around $50,000. The liquefied gas he makes will find a market of varying attractiveness (considering the country at large) but which will yield around 2½ to 4 cents a gallon in the Mid-Continent and 3 to 6 cents in the West. Using a rough estimate, thermal polymerization requires about 3 gallons of butane for each gallon of polymer gasoline



Propane producing column and stabilizer. International Petroleum Company, Ltd., Talara, Peru, South America.

produced. If the gasoline manufacturer already knows, let us say, that he can get 4 cents a gallon for his butane, how sure is he that he can get 12 cents a gallon for his polymer gasoline? He must do so if he is going to equal what he can get for his liquefied gas. In fact, it is reasonable to stretch the point and contend that he has to get more than 12 cents a gallon for his polymer gasoline because he has to amortize a much larger capital investment and carry higher operating expenses than he would in the manufacture of liquefied petroleum gas.

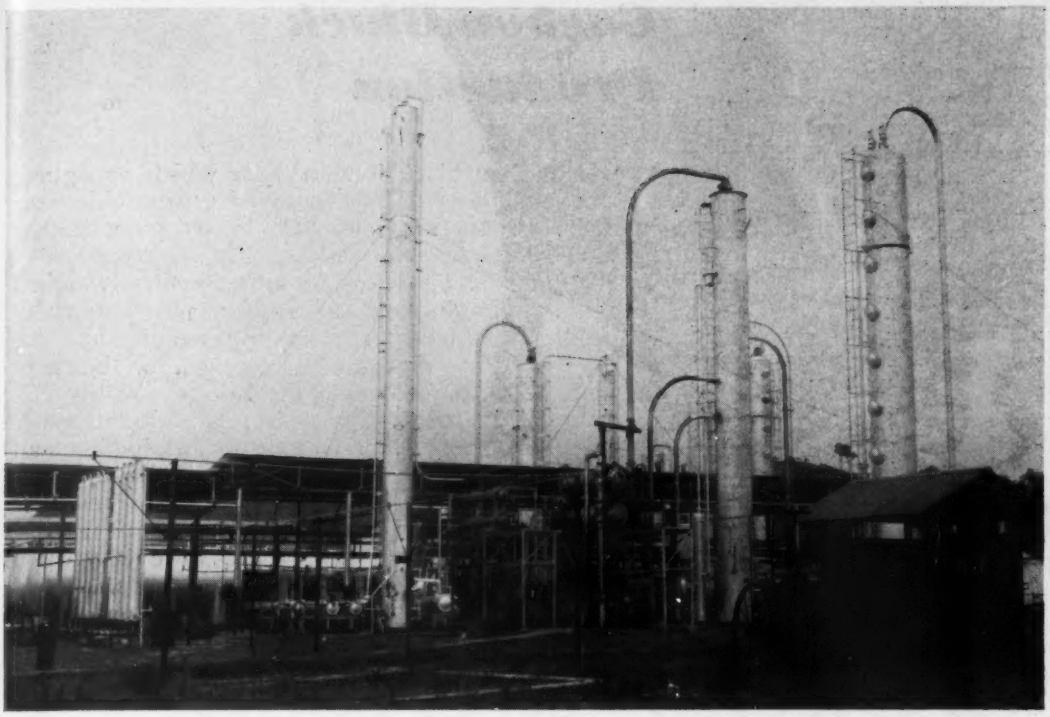
Another factor the gasoline manufacturer must consider is just how well he can afford to develop a supply of propane or butane for polymerization. Taken as a whole there is an enormous amount of propane and butanes available in the Mid-Continent and California, but how centrally located is it? It costs money to transport these light fractions to central treating plants. One of the leading gasoline manufacturers in California has a large gross volume of propane and butanes, but it is spread hundreds of miles all over the state. The same holds true for certain Mid-Continent manufacturers.

What will finally be the marginal value of polymer gasoline? It is difficult to say, but it appears somewhat obvious that it is likely to be as a blending medium. The sale of 82- or 100-octane, straight polymer gasoline would have to be at a price considerably above existing levels. A little short of two years ago one refiner sold some 100-octane polymer gasoline for around 50 cents a gallon. Last year he is reported to have got 23 cents for it. It is reasonable to assume that this year's price will level off somewhat near last year's. But this is for 100 percent polymer gasoline. When considered as a blending stock, polymer gasoline has outstanding advantages. But are they outstanding enough to command a price higher than 70- or 78-octane natural gasoline? Top grade natural sells from 2½ to 5½ cents.

The natural gasoline or liquefied petroleum gas manufacturer who has large surpluses of propane and butanes over and above his established market will undoubtedly become interested in polymerization. It is obvious that if he cannot get rid of his surpluses they have no monetary value with the exception of a possible small value as dry gas. The value as dry gas may be less than the cost of manufacture. From among those with this problem to face will come the gasoline manufacturers, chiefly if not exclusively west of the Rockies, who will pioneer this new phase. In California, polymerization is not likely to become a factor in natural gasoline manufacture for some time yet. Many angles must first assume more definite outlines.

Measurement and Regulation

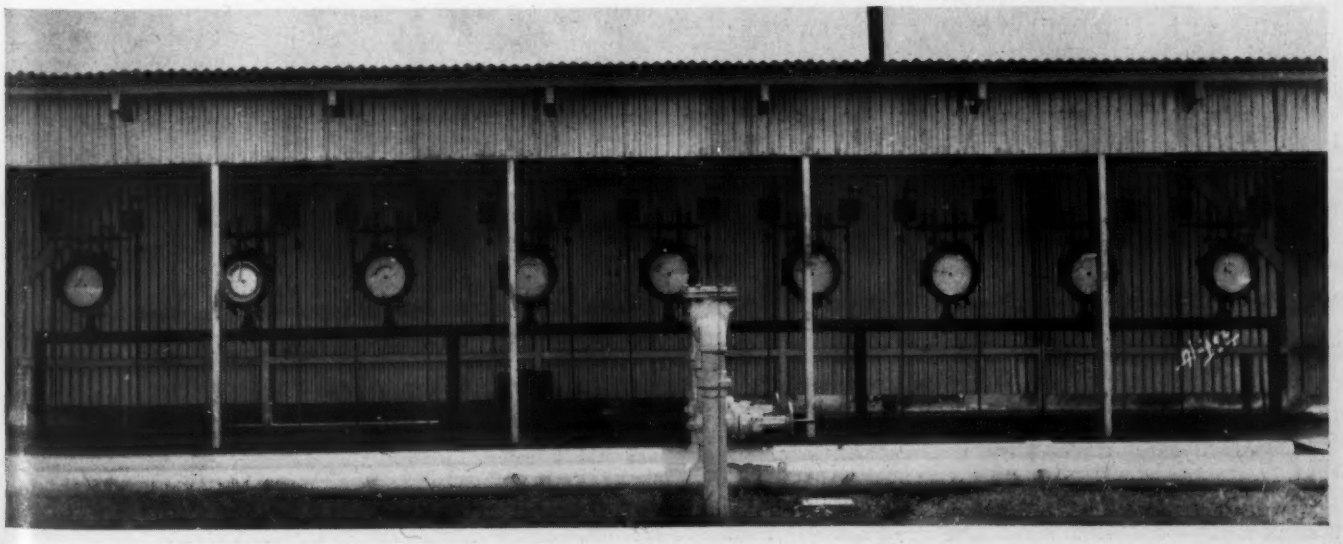
As the results of several years of cooperative research, two technical handbooks on gas measurement have appeared during the past year. One deals with gas measurement by the orifice meter, while the other deals with tentative standards for the determination of superexpansibility (Boyle's Law corrections) factors in high pressure gas measurements. (Bulletins TS-353 and 354, California Natural Gasoline Association.) The metering handbook is based on work done by the American Gas Association and contains a tabulation of the standard nomenclature and constants used in metering; a section devoted to gaseous-flow equations; a comparison of old and



Compania Mexicana de Petroleo El Aquila, S. A., operates the natural gasoline plant shown above in the Poza Rica field, Mexico.

new equations; and meter construction and installation specifications. The text on superexpansibility factors gives detailed instructions for designing deviation apparatus and conducting tests; and presents deviation test curves which have been obtained on a wide variety of gases including hydrogen-methane mixtures, methane, typical natural gases, refinery gases, air, carbon dioxide and nitrogen. A new relationship is shown between Boyle's Law factors and the specific gravity of mixed gases of the natural gas series which may be applied directly to measurement problems without the necessity of costly laboratory determinations.

The adoption of the new American Gas Association procedure for measuring gas by the orifice meter has introduced several problems which are new to many who have used the old orifice meter coefficients. Two of the most radical changes are those which introduce the use of the Reynolds viscosity factor and the expansion factor. It has been pointed out that these two new factors complicate the procedure somewhat because they vary with the rate of flow and, theoretically, cannot be included as part of the meter coefficients for all rates of flow. For ordinary purposes of metering, the Reynolds factor is somewhat more than the expansion factor. Moreover the Reynolds factor varies inversely as the square root of the differential and pressure. The expansion factor is proportional to the actual differential and inversely to the actual pressure. High values of the expansion factor occur at high rates of flow, while the reverse is true for the Reynolds factor. Detailed instructions on the use of the Reynolds number, the expansion factor, and the super-compressibility factor, has been published by the California Natural Gasoline Association in its latest bul-



Gas Metering station in the Poza Rica field, Mexico, showing arrangement of protective seals on the meters. Compania Mexicana de Petroleo El Aguila, S. A.

letin on Gas Measurement which has been published as Bulletin TS-353.

In a committee report presented before the Pacific Coast Gas Association this year, it was pointed out that five principal sources of error in measurement have been found to come under the following classification:

A. "Inaccurate or dirty meter tubes and orifices are adjudged to be the cause of greatest error."

B. "Calibration of the gauges is considered to be next in importance as a source of error."

C. "Third in magnitude are errors in coefficient data such as temperatures, specific gravities, average pressure, and in the standard coefficients."

D. "Errors in reading of the charts are placed next in order."

E. "The mathematical operation in calculation of the coefficients and final quantities are considered to be most accurate of the various steps."

Another alignment chart has been developed for the use of the field gas engineer in solving problems involving the daily volume of plant gases without the necessity of using the numerous calculations made in the chart room. (REFINER, Vol. 15, No. 9, September, 1936.)

In the field of regulators and controllers one development is that of the greatly increased use of the pressure-loaded type of regulator rather than the spring-loaded form. Pressure loading, whereby the direct line pressure of the gas to be regulated is brought against the diaphragm instead of depending upon the tension supplied by a spring, is rapidly doing much to improve the flexibility of regulators. In this important branch of the equipment trade the last few years have done much to stimulate new ideas. Starting with the old weight-counterpoised types, regulators have successively passed through the spring-loaded stage, and now the era of pressure loading will add even more to the already unusual performance of this necessary part of all natural gasoline plant equipment.

Next year will undoubtedly bring increased attempts to make regulators more flexible to adjustments. In times past, the use of regulators and controllers was such as to demand almost a special type for each requirement. But in recent years the goal of the regulator manufacturer has been to design instruments which are flexible over a wider range. For instance, a gasoline manufacturer may want to control a liquid level to within a quarter of an inch; or he may permit a liquid level to vary eight or ten inches and demand a uniform output of liquid. In either case a good regulator should be able to do both jobs. The same would apply to gas and vapors.

Carbon Black Production

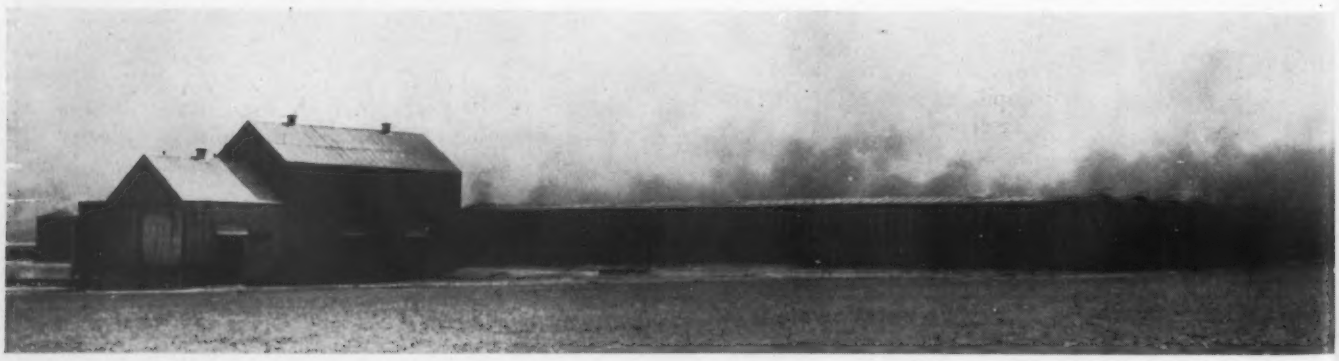
THE carbon black industry, for which no figures are available for 1936, enjoyed a profitable year in 1935. Production was 352,749,000 pounds that year, and total domestic and export sales were 387,536,000 pounds. The increase in demand outweighed the gain in production and stocks were materially reduced. Prices have been holding steadily and the average yield has risen to 1.46 pounds per thousand cubic feet. With economic conditions steadily improving the industry in 1936 is regarded as having held its own from both volume or production and the price standpoint and with the continued improvement in business during 1937 this industry should continue to operate profitably.

At the beginning of 1935 there were 54 carbon black plants in the United States. Texas had 33 plants in the Panhandle section, North Louisiana had 19, Oklahoma and Wyoming each had one plant. Recently two plants have been announced for construction in the Texas Panhandle, and one plant is proposed for western Kansas. Newcomers in the business have been few of recent years and in fact, there were only 21 producers at the beginning of 1936 as compared with 25 producers at the end of 1934.

Average daily production of carbon black in 1935 was 966,400 pounds, with production in 1936 approaching 1,000,000 pounds it is thought. The daily capacity of the operating plants is around 1,500,000 pounds. The industry continues to place chief reliance on the channel process to produce black of desired specifications. An excellent discussion of the producing or manufacturing method employed was published in THE REFINER, Vol. 14, No. 8, August, 1935, page 384—"History, Use and Manufacture of Carbon Black," by R. G. Allen, H. W. Price and E. B. Reinbold. The channel process produces 90 percent of the total annual output.

Carbon black demand is directly influenced by business conditions, as the greater portion of it goes into the manufacture of rubber, ink and paint. The rubber companies consume about 87 percent of the annual production, the ink companies use around 6 percent and about 3 percent goes to paint. The remaining 4 percent goes into miscellaneous products.

The United Kingdom continues to rank first as a purchaser of carbon black from this country, with Germany second largest importer and France third. Canada ranks fourth as an importer with Japan and Italy following in order.



Operating Practices

at Freedom Cracking Unit

FREEDOM OIL WORKS COMPANY, northwest of Pittsburgh, Pennsylvania, in the Borough of Freedom, in the late summer of 1935, built a small cracking unit for the conversion of certain refinery products into higher-octane gasoline. Due to the terrain of this section of the country, with the high, steep banks of the Ohio River on one side, and the river on the other, space was at a premium. In fact, all of the vacant land there had already been used for refinery and other purposes, and to build the cracking plant, involved considerable engineering to distribute the various parts in such a manner that they could be operated without disturbing the remainder of the plant.

This plant is variable in throughput, depending upon the character of the charging stock, but is considered as a 500-barrel plant when operated normally. Stocks which are available for processing are gas oil, foots oil and petrolatum. The general arrangement of the flow is similar to other Dubbs cracking plants but contains no reaction chamber. The furnace is a full-suspended unit, with the floors well above the ground level. Two cells are used in the design, using top-fired burners with the flames adjustable to impinge upon the walls, or, directed upon the tubes themselves, if that type of firing is found expedient. A bridge wall, suspended from the top of the furnace, divides the furnace into the two cells, with the tubes supported nearer the bridge wall than the side walls of the furnace. The burners are placed in tunnels which lie beside the outer walls so that heating may be controlled from the top where the burner valves are situated. The heat given the material passing through the cracking tubes may be further controlled by removing or closing the fuel supply lines to any burner so that selective heating is obtained.

A single tower is provided for the unit, containing both the flash chamber and the fractionating column, the latter superimposed upon the former in such manner that vapors travelling upward pass through both sections before they are fractionated into the various products. As no reaction chamber is included in the plant, cracking time must be controlled within the tubes themselves to obtain the necessary time factor for adequate conversion.

When the plant was first put into operation, the three stocks available for cracking were blended in approximately equal proportions to be charged direct to the tubes of the furnace. At that time it was also thought necessary to bring the unit up to production by charging with gas-oil alone, because it was thought that the heavier material could not be charged as a separate stock without encountering difficulty.

The hot oil pump, a duplex piston-type unit driven by steam, picks up any of the three stocks, either as a separate charge or blended, delivers the fluid to the furnace where it passes through the cells in series. The convection bank of tubes, containing 37 tubes 30 feet in length are placed in the floor of the furnace, where the flames flowing downward from the burners in the roof of the furnace pass over them towards the exit for the combustion gases. These tubes have a wall thickness of ¼-inch, being 3 inches O. D. by 2½ inches I. D., manufactured from an alloy of 4-6 chrome with ½ percent molybdemum. The radiant tubes of the fur-

nace are suspended beside the bridge wall, one side containing a single row, while the opposite side consists of a double row, making 61 tubes in all.

The dual-purpose column, consisting of both the flash chamber and the bubble column, is 5 feet in diameter by 87 feet in height, raised at one end of the furnace, occupying as small an amount of space as possible to prevent interference with other equipment. The tower receives the charge after it has passed through the tubes. The transfer line enters the flash chamber through a pressure-reduction valve, controlled manually from the control room where the instruments are located. In order to obtain this control, a system of rods and universal joints are brought into service, so that the valve can be operated from the stillman's position while reading the pressure- and temperature-control units. The universal joints used are of the needle bearing type, having no backlash so that when a slight turn is made of the control wheel, a like movement may be obtained upon the travel of the valve. The valve is mounted in the transfer line at a point near the combination column, and the control rods with the universal joints lead to a point above the instrument panel. The mechanism mounted upon the yoke of the gate consists of a worm- and full-gear control, placed in a housing so that high temperature lubricants may be used. The apparatus used on the instrument panel to control the travel of the valve, through the medium of the rods and universal joints, consists of a sprocket on the end of the rod, with a chain connecting to a similar sprocket on a stub shaft behind the instrument panel, and at the proper height for ease in operating. A hand wheel is mounted upon the stub shaft with a micrometer control, secured through the medium of gears, so that several complete turns must be made with the wheel to secure a small movement of the stem of the pressure-reducing valve. A dial with an indicator hand is mounted on the hub of the hand wheel. which shows what change is made, graduated in hundredths for accuracy of control.

Cracking arresting is secured by the use of a small quench line connected to the body of the pressure-reducing valve. The charge enters the flash chamber, where two cones are used to operate as stripping equipment. A compartment in the base of the flashing section of the combination tower receives the residuum from cracking, which is continuously processed with steam for accurately stripping the residual volatile fractions carried downward with the stream.

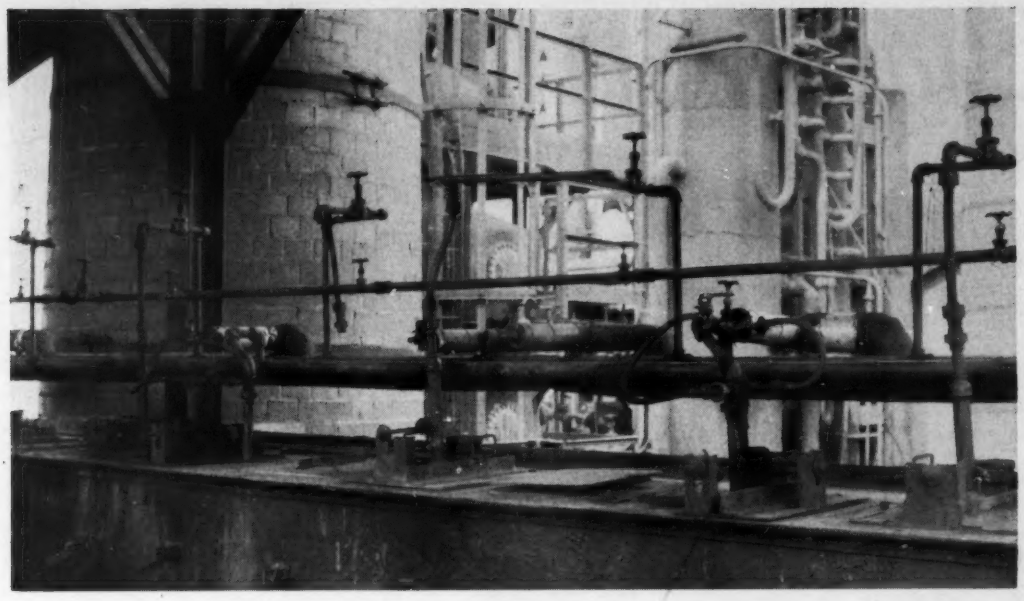
VAPOR-RECOVERY UNIT

The unit contains a vapor-recovery unit, through which the gases not condensed in the regular equipment flow, and meet, in the regulation manner, a part of the charge fed to the cracking unit. Gas oil is used for this purpose even when the bulk of the cracking stock consists of heavier material, such as foots oil and petrolatum, because of the danger of wax formation being stacked upon the trays of the absorber when coming in contact with the cold vapors from the accumulators. This material, along with the remainder of the charging stock is withdrawn from the bottom section of the bubble tower division of the combination column at a point provided with the usual draw-off connections.

When the plant was first put in operation, the stocks, as mentioned above, were pumped by the cold-oil charge pump to the fourth bubble plate in the fractionating section of the combination column, where heat of processing liquefied the heavier fractions sufficiently that they would naturally flow downward to the draw off section where the hot-oil pump takes suction. Operations carried on subsequent to the initial runs demonstrated this not necessary, as any of the stocks are sufficiently fluid to be handled satisfactorily alone. However, as stated above, any operation, whether cracking petrolatum, foots oil or a combination of gas oil, petrolatum and foots oil, gas oil alone is used as an absorbing medium in contacting the gases removed from the accumulator drums at the cracking unit. Very little accumulator drums at the cracking unit. Little difficulty has been had even in extreme could weather by the heavier stocks congealing, due to heating coils in the tanks from which the materials are pumped.

The unit is flexible, and very gratifying results have been obtained, without a reaction chamber, in converting the cracking material to salable gasoline. The operation of a standard cracking plant without a reaction chamber was unheard of a few years past, but due to the arrangement of the furnace, and the placing of the tubes, complete control can be secured at all times of the temperature imparted to the charging stocks passing through the furnace. Cracking temperatures may be obtained in the first cell of the furnace, bringing the heat up to that necessary for economical conversion,

Gasoline exchangers placed behind side stripper and above roof of pump house to conserve space, which is at a premium in the yard of Freedom Oil Works Company.



Burner arrangement on equiflux cracking furnace in Freedom Oil Works Company.

and by maintaining that temperature in the second cell, the reactions necessary can be obtained readily.

INSTRUMENT CONTROL

The control board is equipped with all the essential recording instruments, and in addition, there is an instrument on the control board equipped with a 20-point thermocouple indicator with the leads extending to as many points in the plant. By controlling the pressure, the temperature on the tubes in the two cells and the velocity through the tubes, any type of cracking may be obtained within the scope of the unit. With operation conducted in this manner, there is apparently no need of a reaction chamber in this type of cracking plant.

As the plant is well above the ground level, with the control panel on the roof of the pump building, it was considered that at some time in the future action might be necessary for instant control of the plant, so the drop-out controls were led to one of the brick walls of another part of the plant where they can be manipulated from the ground level. Steam control for fire fighting is included in the layout of the plant, and facilities for operating the gates are placed so an operator may handle them from the ground level.

The roof of the building containing the reflux and stabilizer equipment is sufficiently large, and with a flat surface, supported by brick and steel, so that the exchangers, coolers and other equipment necessary for vapor recovery and stabilization of the cracked gasoline are located there. The accumulator drum which receives the cracked gasoline from the overhead stream removed from the top of the combination column, is suspended from the roof of the pump building, with the upper head behind the control room instrument panel. Pump suction lines from this vessel are consequently shortened, with the discharge travelling only a few feet to the fractionator preheater.

Heating the fractionator reboiler is accomplished by utilizing the residuum from the base of the flashing section of the combination column, passing the necessary portion of this material through the equipment before it enters the residuum coolers on its way to storage. Gasoline leaving the fractionator is cooled and immediately treated with an inhibitor so that it may be thoroughly mixed with the liquid as it travels the full length of the refinery yard to the storage tanks.

To manufacture a finished overhead gasoline, having an end point of around 400°F., the top of the combination column is controlled with liquid reflux to a temperature of about 395°F. It is operated with a pressure approximating atmospheric while the pressure on the transfer line at the point of pressure control is about 400 pounds, gauge. Yields of finished gasoline vary, depending upon the characteristics of the charging stock, but the average is about 70 to 72 percent. Gas oil yields a larger volume of anti-knock gasoline when used as an unblended charging stock, and when mixed three ways, gas oil, foots oil and petrolatum, the yields are about 69 percent. Octane rating of the finished gasoline depends, as in other plants, upon the degree of temperature and pressure maintained in the tubes of the still, and the time and temperature maintained in the second bank of coils located in the second cell. Naturally, the harder the charge is "hit", the higher the octane of the gasoline, and also the higher the temperature the more uncondensible gases are evolved.

Gases not absorbed in the recovery unit are piped to the still where they are burned together with fuel oil. The burners on the roof floor of the top-fired still are adapted for burning both liquid and gaseous fuels. Natural gas for fuel is not available to refiners in this district at prices that are low enough to justify it.

Finished gasoline after being stabilized has the following properties:

Gravity	61.7° A.P.I.
I. B. P.	85°F.
5 percent	110
10	135
20	170
30	205
40	242
50	275
60	310
70	340
80	362
90	382
End Point	405
Recovery, percent	95.5
R. V. P.	9 lbs.

Residuum from the cracking plant averages as follows:

Gravity	19.7° A.P.I.
Flash	210°F.
Fire	340°F.
Pour point	0°F.

Statistical Treatment of
Refinery Problems

J. S. WALTON
Member of Staff
De Florez Engineering Company*

INSURANCE companies rely upon statistical considerations in determining the premiums to be paid for protection. The actuaries of these companies predict with accuracy the probable life expectancy of residents of this or another country. If data is available so that the actuaries can segregate dissimilars such as male and female, white or black, then the predictions made will be still closer to the true life expectancy of such similar groups. The only requisite for extreme accuracy of such predictions is a sufficient number of case histories, the accuracy of the prediction increasing with the number of data.

Likewise a physicist can, by studying a cubic foot of gas, estimate the average behavior of each molecule in the gas body; but if he had available for study only one atom or one molecule of this gas, then his predictions for the behavior of other similar particles might be, and probably would be, completely at variance with fact. Indeed according to the "Principle of Uncertainty" as formulated by Heisenberg[7], knowledge of the behavior of individual particles such as electrons may be forever unknown, because the act of observing such minute bits of mass or energy exerts sufficient influence upon the particle to completely alter its character.

Petroleum with its countless constituents should

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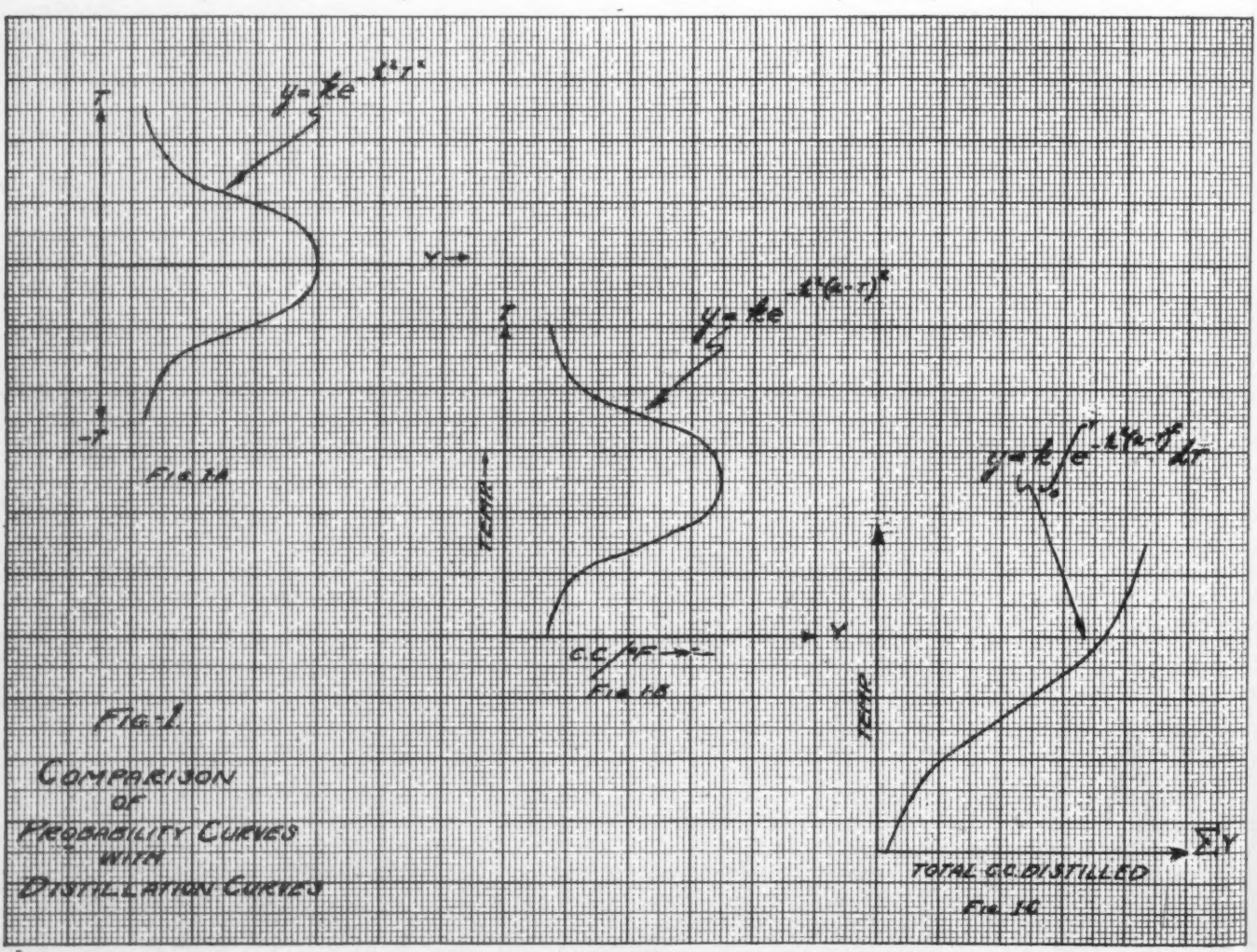

FIG. 1
COMPARISON OF PROBABILITY CURVES WITH DISTILLATION CURVES

FIGURE 1

STATISTICAL computation oftentimes is the most reliable means of predicting the behavior of a system. In any system there is no such thing as random behavior, but the comprehension of all the factors causing a certain course of events in a complicated system usually is impossible. It then becomes necessary to resort to statistical methods in order to chart the probable course that the system will follow.

It is a characteristic of all such mechanisms, that the greater the number of individual similar parts comprising the system, the more amenable to statistical treatment the system becomes, regardless of whether the objects under observation be animate or inanimate, intelligent or irrational. Also, as would be expected, the more similar the individual parts of the entity, the more accurate will be the deductions as to the group behavior.

offer a fertile field for statistical investigation, for as stated in the foregoing paragraphs, the larger the number of individual parts comprising the system, the more accurate should be the deductions as to the behavior of the whole. Yet there are certain limitations imposed upon the accuracy which should be expected from such a method of study. In the first place petroleum is not made up of one homologous series of paraffins, olefins, naphthenes, or aromatics. It is a complex mixture of some of each of these groups and more. Therefore the accuracy of prediction will be limited. Again petroleum as observed in the laboratory is not complete. Some of its original constituents are gone; evaporated during the course of capturing the oil. This again should adversely affect the accuracy of the results to be expected. Finally with the complex mixture, the analysis of results will be somewhat in error due to the human element, and the inability of human hands to correctly measure the quality or quantity of the oil under examination.

It is the purpose of the following discussion to show how some methods of applying probability to refinery problems have been devised and used, and to suggest other possible methods of attack, using statistical considerations as the avenue of approach to the problem.

DISTILLATION OF OILS

If a petroleum oil is batch distilled, the quantity of distillate obtained for a definite temperature interval will increase as the distillation proceeds until a certain temperature has been reached. After this point the rate for the temperature interval will gradually decrease until the end of the distillation has been reached. If this distillate rate per degree is plotted as an abscissa with the temperature of distillation as an ordinate, the differential curve so obtained will be similar in shape to the curve of Figure 1-B. This type curve will be called the distribution curve of the oil in question; because it portrays how the various fractions are distributed over the distillation range. If now the quantities of distillate obtained are cumulatively added for the same distillation, and the various sums plotted again as abscissa versus the same temperature ordinate scale, the cumulative distillation curve will have the same general shape as the curve in Figure 1-C. This curve will be readily recognized as being similar to the familiar A.S.T.M. distillation curve, or to a True-Boiling-Point Curve, and indeed this is what it represents, for each of the two types of curves mentioned are cumulative percentages of distillate plotted against the temperature of distillation.

Curves of the shape of Figures 1-A and 1-B are by no means rare. They represent a graphical tabulation of almost any set of data. This shape curve is known as the probability curve or the normal error curve, and when symmetrical about the y axis, as in Figure 1-A, can be represented by the equation

$$\text{I} \qquad y = ke^{-h^2T^2}$$

In order to transpose the curve in Figure 1-A to the curve of 1-B, it is necessary to add a constant to the exponent of equation I. The equation for the curve of Figure 1-B then becomes

$$\text{II} \qquad y = ke^{-h^2(a-T)^2}$$

and according to the previous paragraphs, equation II should come close to representing the distribution curve for an oil.

Similarly in Figure 1-C the equation for the curve is

$$\text{III} \qquad y = k\int_0^{T-h^2(a-T)^2} e \; dT$$

and this equation should be applicable in describing an A.S.T.M. or a True-Boiling-Point curve. In order to test the accuracy of this hypothesis, a special graph paper will be used. The ordinate scale of the paper will be foreshortened according to the reciprocal of the absolute temperature, and the abscissa will be scaled according to the values of the probability function. This latter method of using the probability scale was devised by Hazen and described by him as follows [1]:

"Spacings of the lines for this paper were computed from values of the probability integral taken from tables.——The 10 percent line is the same distance from the center of the paper as the 90 percent. Then 10 percent of all the results will be outside these two lines on each end of the paper making 20 percent in all. On page 221 of Merriman's Least Squares is found a table of values for the probability integral. In this table the values of x/r (ratio of actual variation to the probable error) corresponding to 0.80 is found to be 1.9. This figure therefore may be taken to represent the distance of the 10 percent and the 90 percent lines from the center of the paper."

The chief value of this type of paper is that any set of data which assumes the shape of a probability curve such as that of figure 1-A, will plot as a straight line on the sheet of especially scaled probability paper. Therefore an A.S.T.M. distillation curve or a True-Boiling-Point curve should be represented as a straight line on the paper. Before trying out an actual distillation curve a change will be made in the ordinate scale because on Figures 1-B and 1-C a linear temperature scale has been shown. Actually vapor pressure is the true measure of the volatility of a substance and the relative volatilities of similar members of a hydrocarbon series are the ratios of their vapor pressures. This relative vapor pressure relation (volatility) changes as the temperature changes and the change bears a relationship to the reciprocal of the absolute temperature. Accordingly a reciprocal temperature term will be sub-

stituted for the T in the exponential term of equations I and II. Equation I now becomes:

IV $$y = -ke^{-h^2/T^2}$$

Equation V is changed to

$$y = -ke^{-h^2(a^{-1}/T)^2}$$

and equation III becomes,

VI $$y = -ke\int_{o}^{T} e^{-h^2(a^{-1}/T)^2}\,dT$$

where y = the percent distilled,
T = absolute temperature degrees Rankine, and a, k, and h are constants which are characteristic for each oil.

Table I shows the results of a very carefully conducted batch distillation of a Mid-Continent crude oil.

This distillation was carried out with the distillation pressure so regulated that the oil temperature did not exceed 700° F., and only reached this maximum temperature at the extreme end of the distillation. During the lowest pressure interval the distillation flask was electrically heated so that heat losses would not necessitate excessive liquid temperatures, and the distillation rate was slowed to minimize entrainment. As a result of these precautions even the last overhead fraction possessed a clear color, and the asphalt residue was of a distinctly straight-run character and had a good low-temperature ductility and low penetration ratio.

TABLE 1

Distillation of Hollow Pool Crude—Kansas

Fraction Number	Maximum Temperature, ° F.	Pressure mm. Hg.	Corrected Temperature to 740 mm. Hg.	Cumulative Volume, Percent
Loss	...	...	....	0.9
1	122	740	....	3.1
2	167	740	....	7.73
3	212	740	....	13.85
4	257	740	....	19.69
5	302	740	....	26.5
6	347	740	....	34.9
7	392	740	....	39.7
8	437	740	....	46.1
9	482	740	....	51.7
10	527	740	....	57.7
11	462	37	662	73.2
12	566	15	820	77.9
13	618	18	890	81.8
14	625	4.5	965	87.1
15	588	0.6	1,100	89.6
16	620	0.5	1,148	91.7

Figures 2A and 2B show the result of plotting this distillation from Table I on Hazen's probability paper. The ordinate scale has been made into a reciprocal temperature scale as was previously mentioned. Figure 2-A shows the complete distillation up to the 91.7 percent overhead, and Figure 2-B has been made on a large scale in order to show deviations more plainly. It will be noted that all the points fall fairly close to the straight line drawn among the points, the maximum deviations occurring at the upper end of the distillation range. Some de-

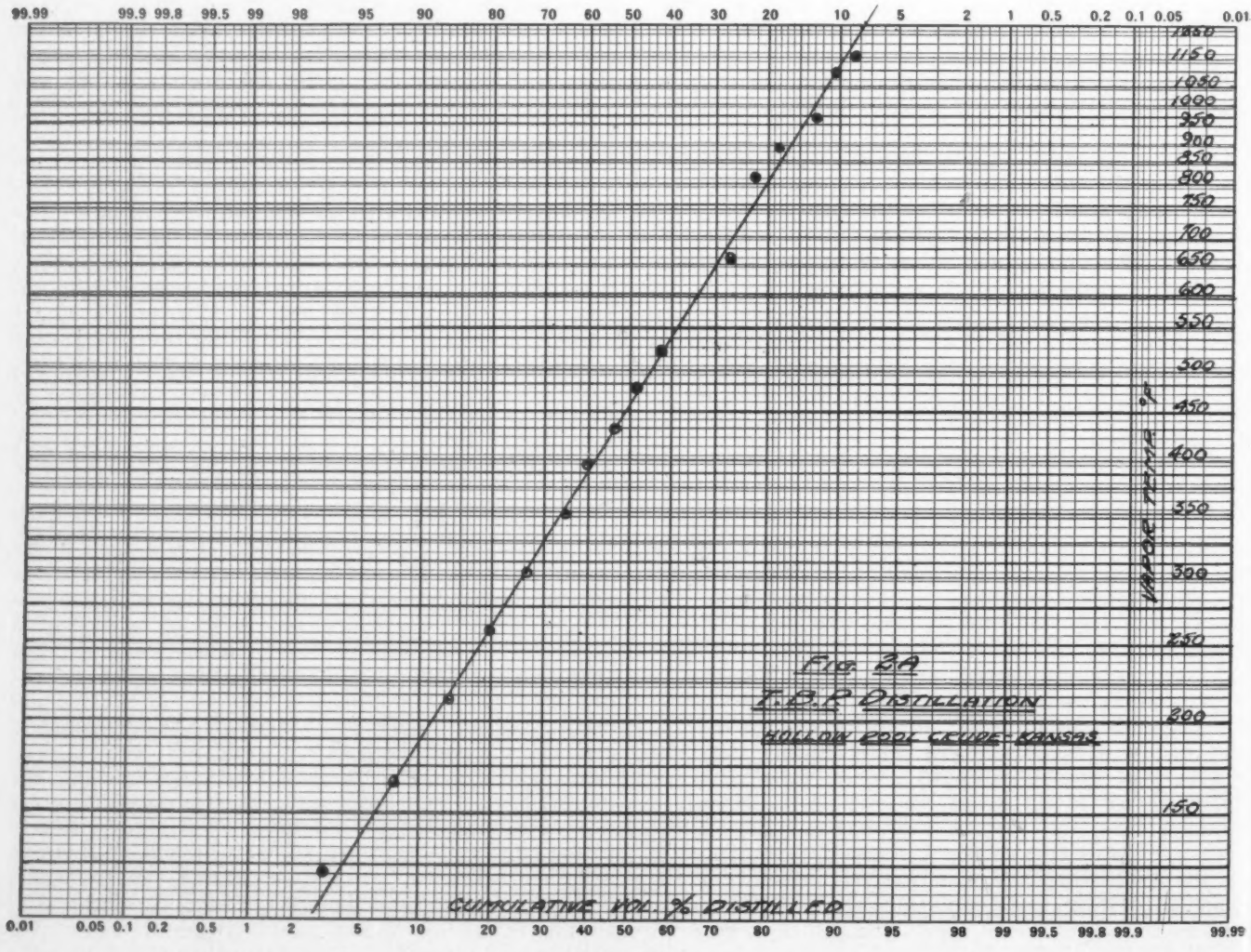

FIGURE 2-A

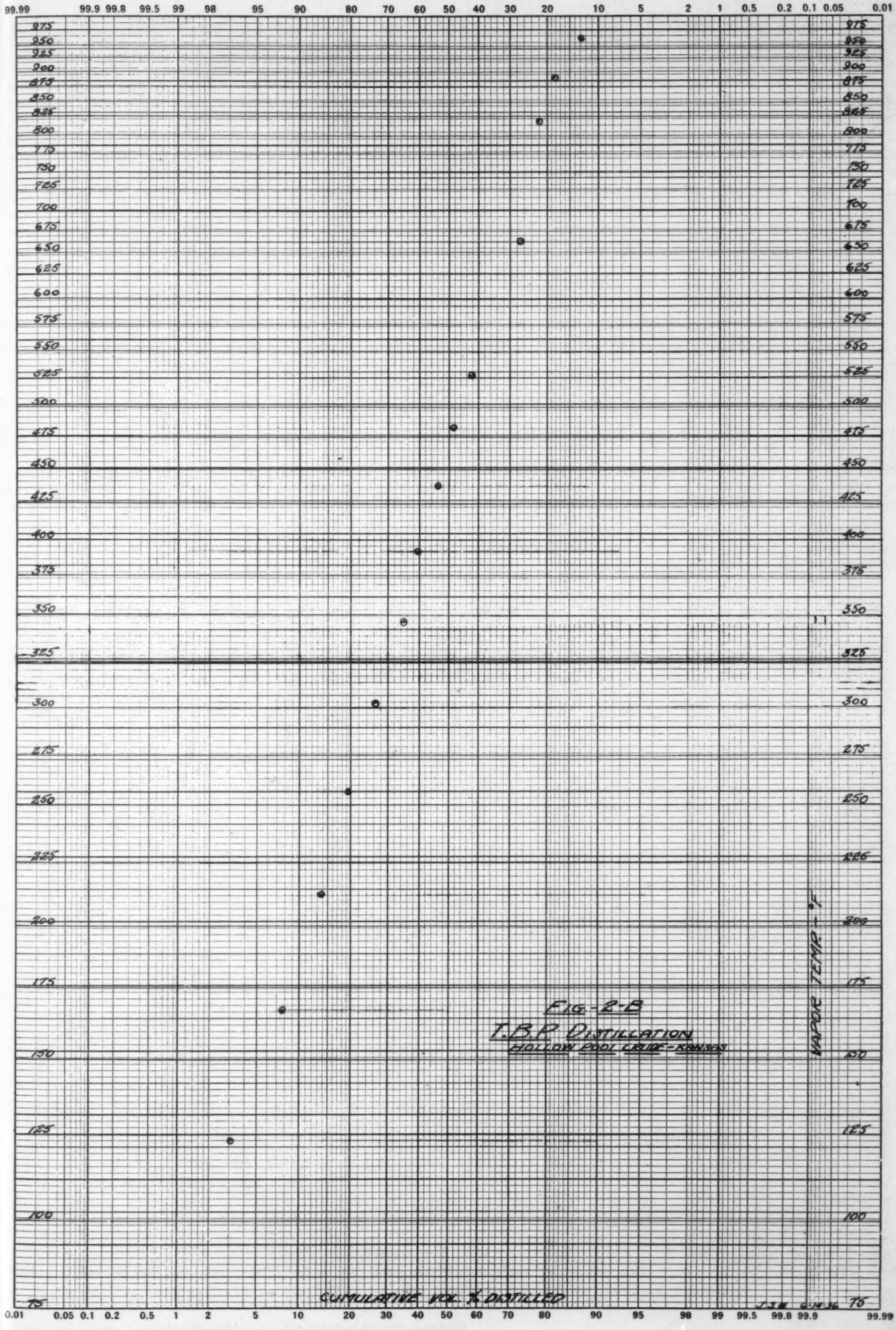
99.99 99.9 99.8 99.5 99 98 95 90 80 70 60 50 40 30 20 10 5 2 1 0.5 0.2 0.1 0.05 0.01
975 950 925 900 875 850 825 800 775 750 725 700 675 650 625 600 575 550 525 500 475 450 425 400 375 350 325 300 275 250 225 200 175 150 125 100 75
VAPOR TEMP °F
CUMULATIVE VOL % DISTILLED
0.01 0.05 0.1 0.2 0.5 1 2 5 10 20 30 40 50 60 70 80 90 95 98 99 99.5 99.8 99.9 99.99
FIG-2-B
T.B.P. DISTILLATION
HOLLOW POOL CRUDE - KANSAS

FIGURE 2-B

viation would be expected in this range because of the error in converting the distillation temperature at 0.5 mm. pressure to the equivalent temperature at atmospheric pressure, not only because of the doubtful accuracy of vapor-pressure charts over this extreme range, but also because of the differences in volatility ratios between the light and heavy oils in the distillation flask when the pressure of the distillation was lowered at the end of collecting a fraction. This is more simply explained by saying that an equilibrium between all the components in the mixture would not be the same at different pressures, and that even if the distillation had been carried out at perfect equilibrium conditions, yet due to different slopes of the vapor-pressure lines for different components, the equilibrium conditions would be changed at different pressures.

Even with these inescapable errors the line seems straight enough so that extrapolation would have been reasonably safe had the distillation not been carried past the 40-percent point or even the 30-percent point. Several of these careful distillations have been made on various crudes down to asphalt and in every case the points fall on a good straight line, although the first point sometimes shows a tendency to fall somewhat to the left of the remainder of the points.

The inference to be drawn from the foregoing paragraph is that if a very careful distillation is carried out at atmospheric pressure up to the 30-percent or 40-percent point, then the remainder of the distillation can be safely extrapolated through the entire distillation range.

As a check upon the method, some of the distillations of crudes as carried out by Bureau of Mines investigators have been plotted on Figures 3 and 4. No values for distillation losses are given in the Bureau's publication[2] so a figure of 1.5 percent loss has been assumed in each case and added to the first fraction. It should be noted from Table I that the distillation loss of 0.9 percent has been included in the cumulative values for percentage distilled. This low loss for a distillation of a light crude down to asphalt will give some indication of the care with which the distillation was conducted. It should also be noted that very dissimilar crudes were chosen for plotting from the Bureau of Mines bulletin, and that the crudes range from a very heavy hybrid crude, to a Kentucky paraffinic crude (Figure 3), and include two naphthenic crudes from the same field but different sands, (Figure 4).

The two crudes shown on Figure 4 are both naphthenic crude (according to the Bureau of Mines system of classification[2] and both are from the same field, yet the slopes of the lines are considerably different. It will be shown later that the slope of the lines for various oils are an indication of their characteristics, but for the present Figures 3 and 4 will be considered merely as an indication that the distillation of a crude oil may be represented as a

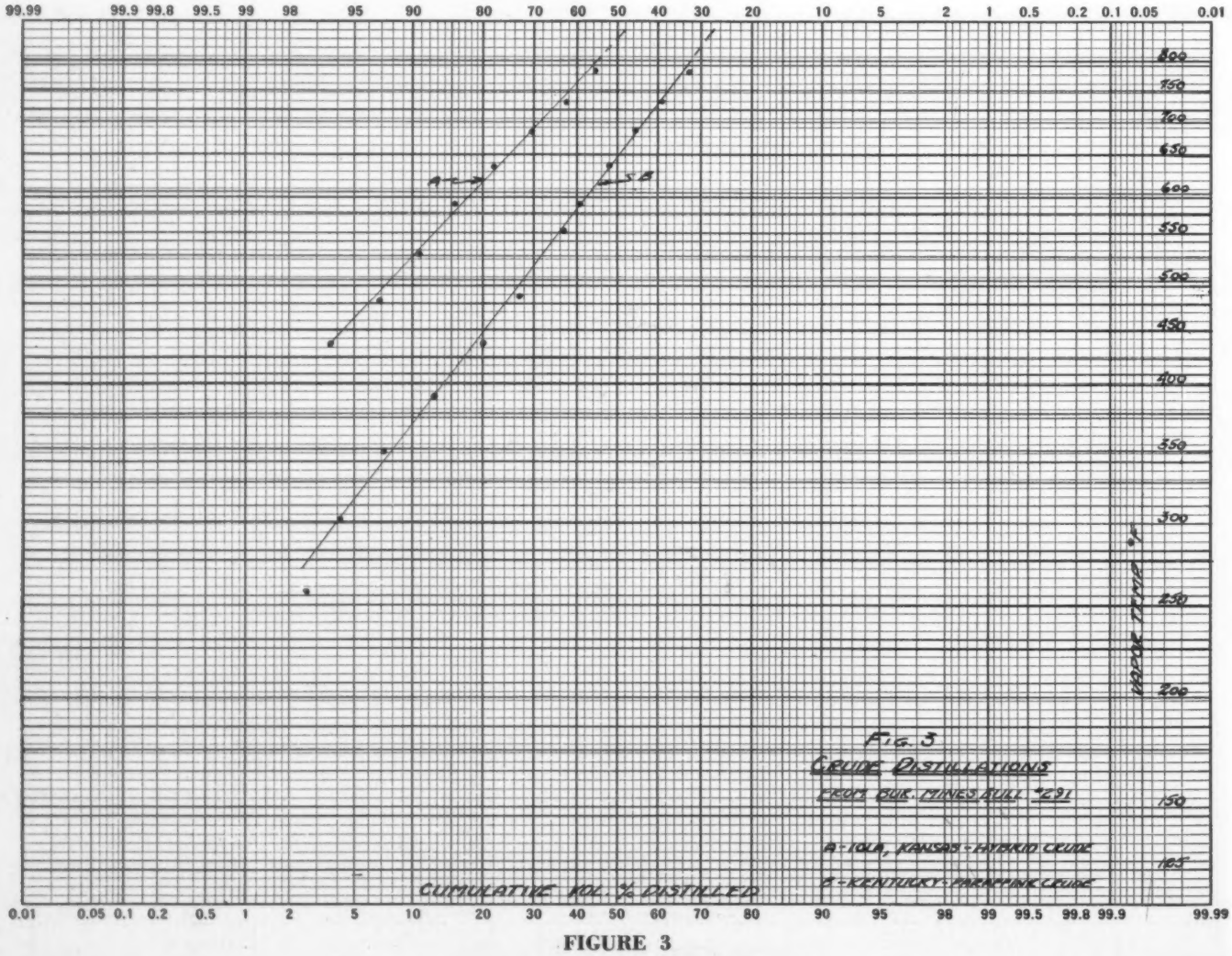

FIGURE 3

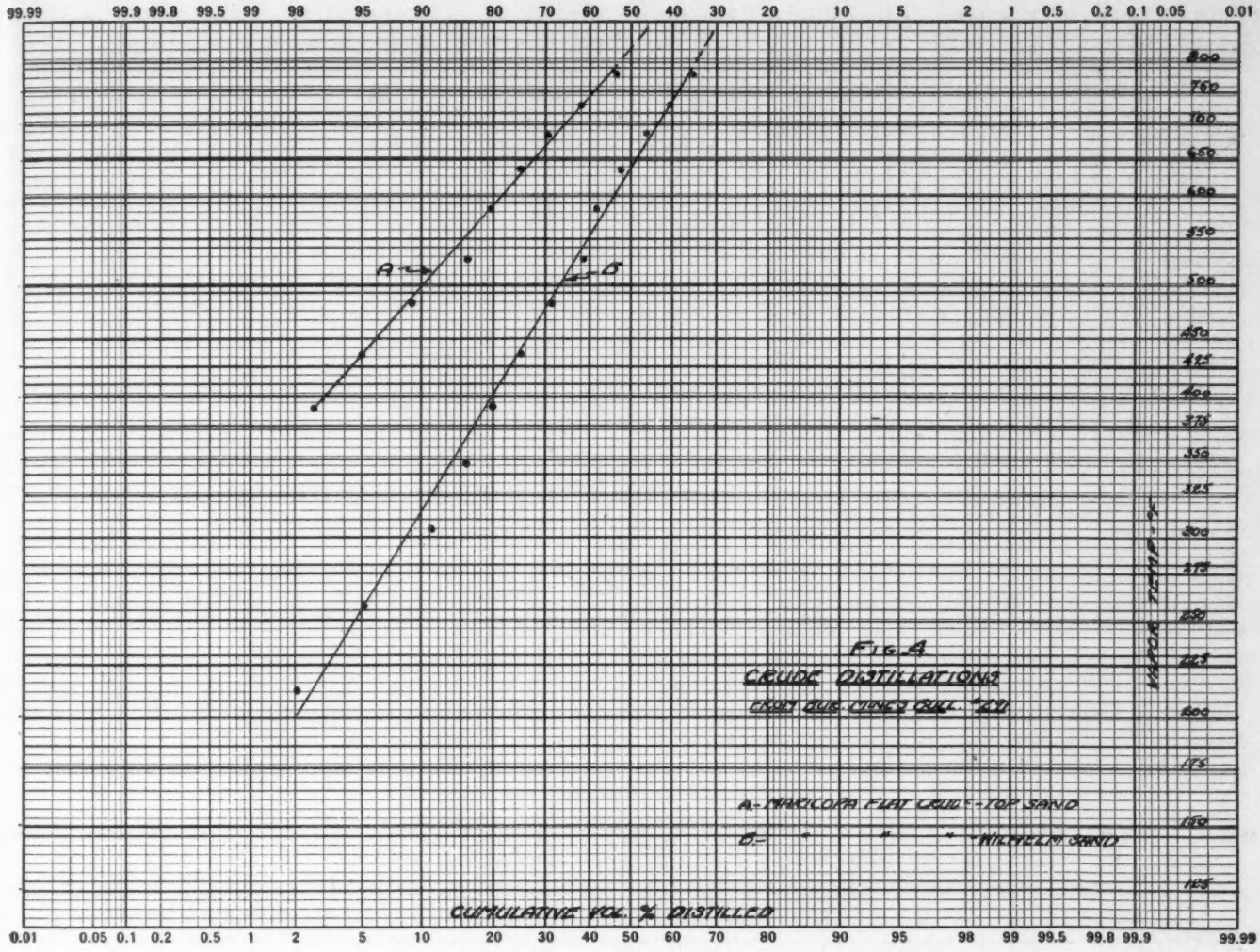

FIGURE 4

straight line on paper constructed as previously described. Furthermore Figures 3 and 4 serve to show that data from various investigators all give comparable results. It is doubtful if extreme care to maintain constant distillation pressures was exercised in the Bureau's distillations, since their problem was to classify crudes and not to attempt to secure exceptionally uniform fractions. Also as stated previously no figures for losses are given in the Bureau's publication and therefore the assumed value of 1.5-percent loss may be considerably in error. These factors probably partially account for the fact that the crudes shown in Figures 3 and 4 deviate to a slightly greater extent from a straight line than the crude of Figure 2.

It has not been the intention of the foregoing discussion to state that all crudes will plot as a straight line upon the probability-reciprocal temperature paper. It is probable that some abnormal crudes would show curvature either at the upper or lower ends of the distillation. To date no crudes have been found by the writer which do not give a fairly good straight line agreement but some naphthas have been found which give some curvature. These are usually of the highly weathered or blended types, and as would be expected their distribution curve (Figure 1-B) is not normal over that part of the curve where certain fractions have been added to or deleted. It is believed that all "normal" oils can be represented on the described paper by a substantially straight line. By a normal oil is meant any oil which has been fractionally distilled and condensed so that no portion of the oil has been added to or subtracted from by conditions other than those approaching equilibrium. Crude oils may be considered to be normal since the condition under which a crude collects must be a nearly perfect example of equilibrium. If a naphtha has been highly weathered without fractionation, or if two dissimilar naphthas have been blended, then it would be a coincidence if such a product should contain "normally" distributed fractions.

Figure 5 shows the A.S.T.M. distillations of several widely different oils and naphthas from various sources. The A.S.T.M. distillation is by no means an accurate analytical procedure, yet such is the nature of the cumulative method of plotting, that an error in one fraction is to a large extent compensated for in the fraction preceding or following the one erroneously measured. Also when the best straight line is drawn through a set of points, the error of one bad point is partially discounted by the compensating error in a preceding or following point. In each of the distillations on Figure 5 the loss has been added to the first fraction as was done in the case of the crudes. Note that in the case of the kerosene fraction the slope of the line is much flatter than in the case of the cyclic oils, and serves to show the closeness of fractionation. The straight-run naphtha plotted was intended for a reforming stock and the

lower end of the distillation curve was not carefully fractionated.

Contrasted to the apparently satisfactory agreement with normal distribution of the products shown in Figure 5, the naphtha in Figure 6 shows a curvature at the upper end of the distillation curve. This naphtha is a blend of a straight-run product, a cracked distillate and a small quantity of absorption gasoline for summer-specification gasoline. The light fractions present in a small amount for summer specifications give the first part of the curve a steeper slope than the later portion where the heavier stabilized blend starts to exert its influence upon the the distillation curve. As stated previously, in a blend of this sort a normal distribution curve would be a coincidence. Deviation from a straight line of such a blend gives an indication of the soundness of the method for normal mixtures.

PRACTICAL APPLICATIONS

IT HAS been demonstrated that the distillation curve of a normal oil can be closely represented by a straight line on a specially constructed paper. The utility of such a method of depicting distillation curves has not been enlarged upon, but the writer has found many applications, a few of which will be discussed. Other uses have presented themselves to mind but insufficient data have been tested to ascertain if these uses are practicable.

In the design of vacuum equipment for crude distillation it is desirable to have an accurate crude evaluation down to the required percentage residue. In the case of asphalt manufacture from light crudes, these percentage residues oftentimes are as low as 6 percent. A laboratory distillation down to the desired point is extremely laborious and time-consuming even with a permanent laboratory vacuum installation. Furthermore there is always the necessity of using extremely low pressures if cracking is to be avoided, and this entails performing the distillation in two or three steps in different equipment, because low-pressure equipment is not suitable for the early stages of a distillation. Transfer of oil to several pieces of equipment means spillage losses, and other errors.

By means of the described special probability paper it appears possible to distill a crude or any other normal oil up to approximately the 50-percent point (or only to 30 percent if desired) by atmospheric distillation, and to extrapolate the remainder of the distillation to the desired percentage bottoms, thus eliminating the most laborious and time-consuming part of the distillation. Furthermore, considering the good agreement obtained on distillations carried up to a high-percentage overhead, it appears that the accuracy of such an extrapolation should be as good as needed for design purposes.

It will be noted in the distillation shown in Table

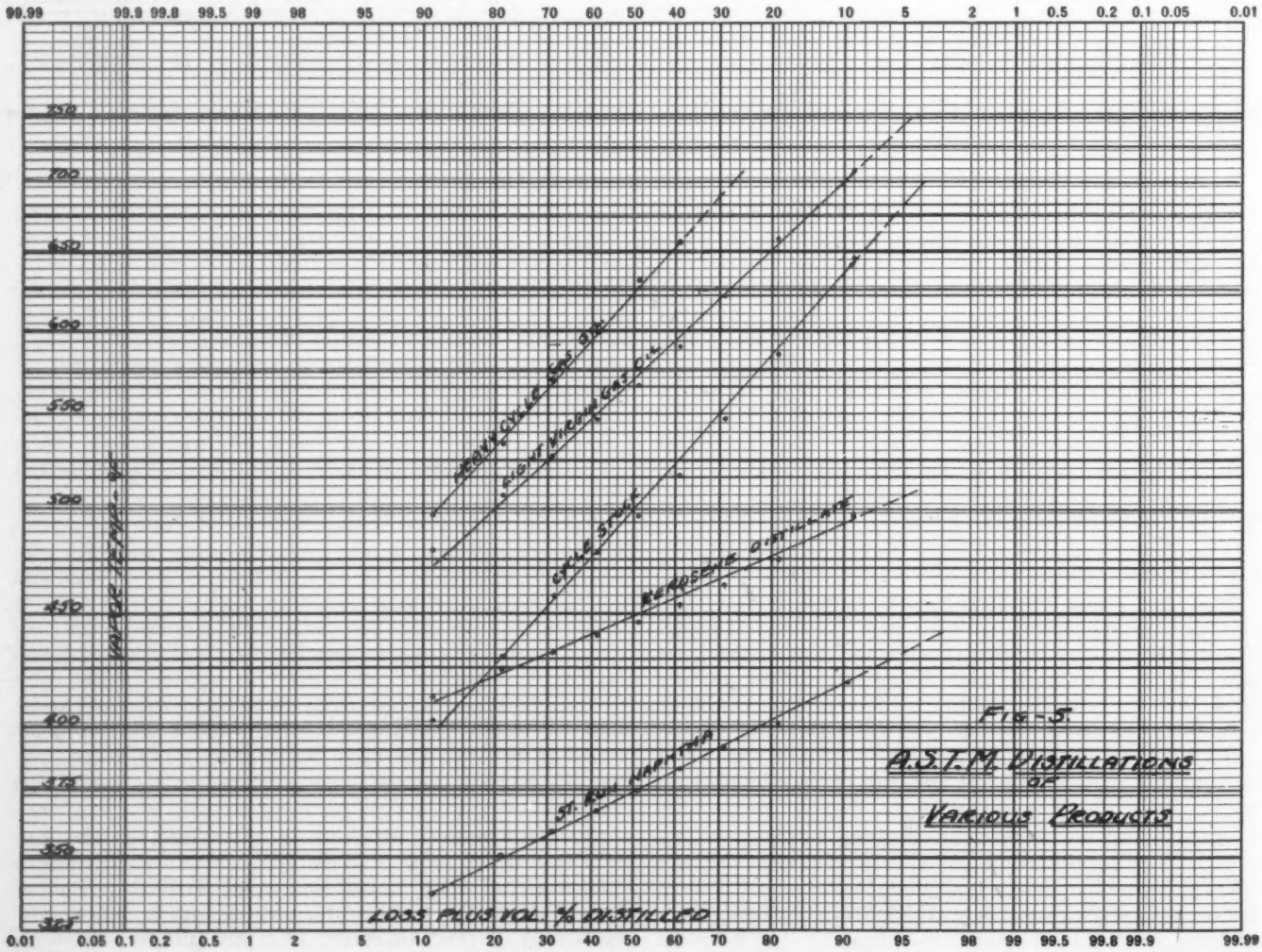

FIGURE 5

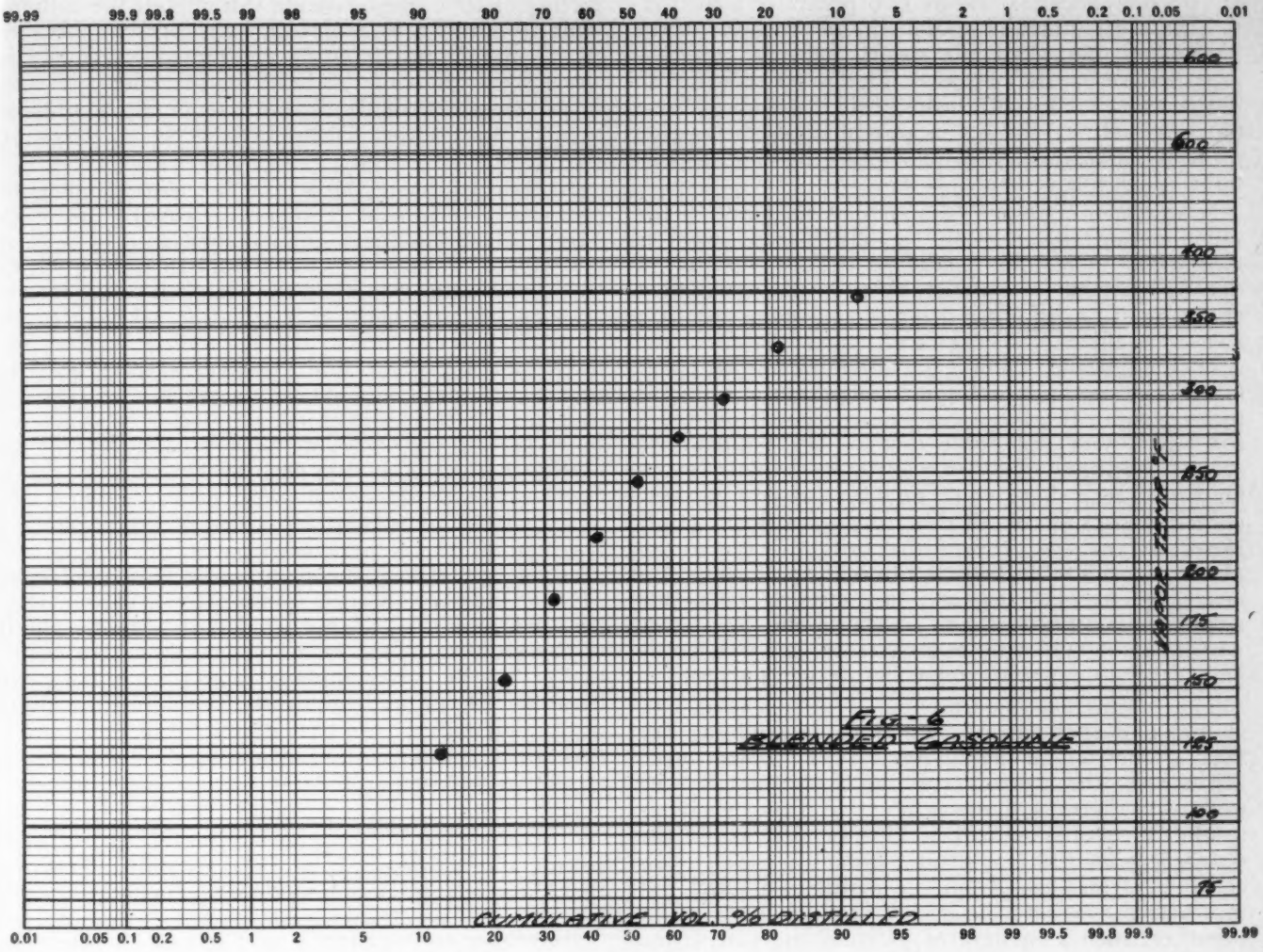

FIGURE 6

I that pressures as low as 0.5 mm. mercury were used in securing a 91.7 percent overhead distillate. Accurate vapor-pressure charts for these extremely high-boiling compounds are not available, but in correcting the temperature of 0.5 mm. pressure to 740 mm. pressure the method of Maxwell[3] was used. This method makes use of a reciprocal temperature relationship and is based upon the vapor pressure of hexane. Maxwell uses the equation

$$\text{VII} \qquad \frac{1}{T_n} = \frac{a}{T_{hexane}} + b$$

where Tn = absolute temperature of the compound
Thex = absolute temperature of hexane when
Pm = Phexane.

and if the constants a and b are known the vapor pressure chart can be extended to as low a pressure as the data for hexane allows. These constants can be calculated by using known vapor-pressure data for some other compound such as pentane. The equation for the vapor pressure of hexane in this low pressure region is[4]

$$\text{VIII} \qquad \text{Log}_{10} P = -\frac{.05223A}{ok} + B$$

where P = pressure in M.M.
A = 36,702
B = 8.782 and
K = absolute temperature on the centigrade scale

Using this equation and equation VII the vapor-pressure chart can be extended to the range desired. This was done in the case of Table I and the corrected temperature of 1148° F. was thus arrived at, which when plotted on the special paper allows the straight line representing the distillation curve of the crude in Figure 2 to be extended to 91.7 percent overhead.

With the fact established that the distillation curve plotted to more than 90 percent overhead gives a substantially straight line when using Maxwell's method, the estimation of vapor pressures for heavy fractions of other crude can be accomplished as explained by extrapolating the distillation curve to the desired percentage overhead and then reading off the desired vapor pressure-temperature relation from any reliable extended vapor-pressure chart such as the one devised by Maxwell.

Another way in which the described method of plotting distillations has proven itself valuable is in the estimation of distillation curves for oils when insufficient data is available for the complete distillation curve to be drawn. Sometimes only the A.S.T.M. distillation curve for the oil is available and these distillations are decidedly inaccurate when plotted as a conventional type curve. If plotted as the best straight line on the probability paper, doubtful points can be discarded with much more assurance than if the distillation were plotted as a curve. Oftentimes also, data is incomplete with only a portion of the distillation curve known such as the percentage over

at two temperatures. While two points of a distillation would be almost useless in plotting a curved line, when plotted on the special paper a good approximation can be obtained. This practise is not to be recommended except when other data is lacking but in such cases this approximation method is probably more accurate than any other and is certainly more convenient.

It has been previously stated that the slope of the straight line representing the distillation curve is indicative of certain characteristics of the oil in question. In the evaluation of a crude oil certain characteristics are desired for certain purposes. If a large amount of cracking stock or lube stock is desired in a crude, then a flat slope with the curve lying well up in the higher temperature range is to be desired. If a large gasoline content is desired a flat slope with the curve low on the temperature scale is desirable, and for road oil or asphalt manufacture a steep slope would be desirable. While these characteristics are obtainable from an ordinary crude break-up, yet it is believed that with this method of plotting, a better picture of the economic value of a crude can be obtained, and furthermore the actual slope as measured from the paper is a concrete figure which can be stated to be a characteristic of a crude and serves to define its value for a given purpose.

The production departments of oil organizations should find such charts helpful in determining the source of an oil. In the laboratory the problem often arises as to the horizon from which an oil has been produced. Figure 4 shows production from two sands in the Maricopa field in California, and while the differences in the two crudes would be easily discernible in this case from the distillation itself, yet in other cases where the initial fractions were nearer together, such a method of plotting the distillation curve would strikingly illustrate the differences in crudes from different sources or horizons.

The use of the special paper for plotting distillation curves should prove a helpful adjunct to investigations into the constituents of petroleum. Usually such projects are initiated by subjecting the oil being analyzed to a very careful fractionation into very narrow cuts. These cuts are then redistilled and perhaps subjected to fractional crystallization in order to segregate the individual components. If such a fractionation were to be plotted on a probability chart, points lying farthest away from the straight line would indicate the presence of a larger than ordinary fraction, or else an absence of an expected amount of material boiling in that range.

Finally, there is the undeveloped possibility that such a method of plotting distillation curves might be of considerable value in determining fractionating efficiencies of various types of plates and fractionating towers. This problem is now being investigated with several allied objectives. First since the equilibrium vaporization of an oil is a function of its width of boiling range (slope of distillation curve), a straight-line slope should be helpful in predicting equilibrium conditions of vaporization. Also in a fractionating column where equilibrium conditions are approached and where various fractions are closely cut, a plot of the distillation curves of fractions from each tray should give a family of lines whose slopes and intercepts would portray the closeness of fractionation obtained and give an excellent picture of conditions existing throughout the column. This would be a helpful adjunct to present methods of calculating fractionating equipment, especially in the fractionation of the heavier cuts where less information is available and where the great number of constituents would lend themselves to statistical treatment.

In measuring the slope of a line plotted upon the probability-reciprocal temperature paper it is much easier to use the linear slope as measured by regular coordinates, rather than to attempt to determine the "h" exponent in Equation VI. This is true for several reasons, the first being that equation VI is integrated with difficulty unless one is familiar with hyperbolic functions. Next the exponent $(a\text{-}1/t)^2$ evolves into a very small number which necessitates the use of large negative logarithms. If however, it is desired to evaluate these constants for any particular oil the easiest method is to first find the "k" and "a" terms from a plot of the distribution curve—Figure 1-B. These distribution curves are best made by plotting the distillation on the special paper, drawing a best straight line among the points, and then read from the line the size of each fraction for a chosen temperature interval. "K" is then found to be the value of the abscissa at the maximum point on the curve, and "a" is the corresponding value for 1/t. This can be easily shown mathematically by finding a maxima on the curve from the first derivitive of equation V representing the distribution curve.

$$\text{V} \qquad y = -ke^{-h^2(a-1/T)^2}$$

$$\text{IX} \qquad dy = 2h^2ke^{-h^2(a-1/T)^2} \frac{.(A-1/T)\,dT}{T^2} = O$$

setting this first derivative equal to zero it is found that there is a maximum at the point where

$$a = 1/T$$

Returning to equation V and setting "a" equal to 1/T, then

$$y = ke^{\circ} = k$$

so that "k" equals the percentage distilled at the maximum point where

$$1/T = a$$

Once having found "k" and "a" for an oil it is comparatively simple to evaluate h by substitution. Because of the exponential form of Equation V, the distribution curve from which "a" and "h" are read should be constructed carefully and on a large scale, otherwise "h" will not be found to be constant over the whole distillation range.

CORRELATION OF CORROSION DATA

The use of a statistical treatment for correlating corrosion rates is not new. Several investigators have published results of corrosion studies, using Hazen's paper in plotting their results. Passano and Hayes[5] have published a description of investigations of corrosion of metal strips immersed in various tap waters. They were able to show that the rate of failure of such metal strips follows the probability curve, and therefore plots as a substantially straight line on the special paper. In constructing their chart the elapsed time before failure of the strip was plotted as the ordinate, with the cumulative percentage failures as the abscissa. Much of the nomenclature used by these two authors has been retained in this discussion. Similarly Griswold[6] has used the same method of treatment in studying the life of buried pipe, and found that the failure of pipe sec-

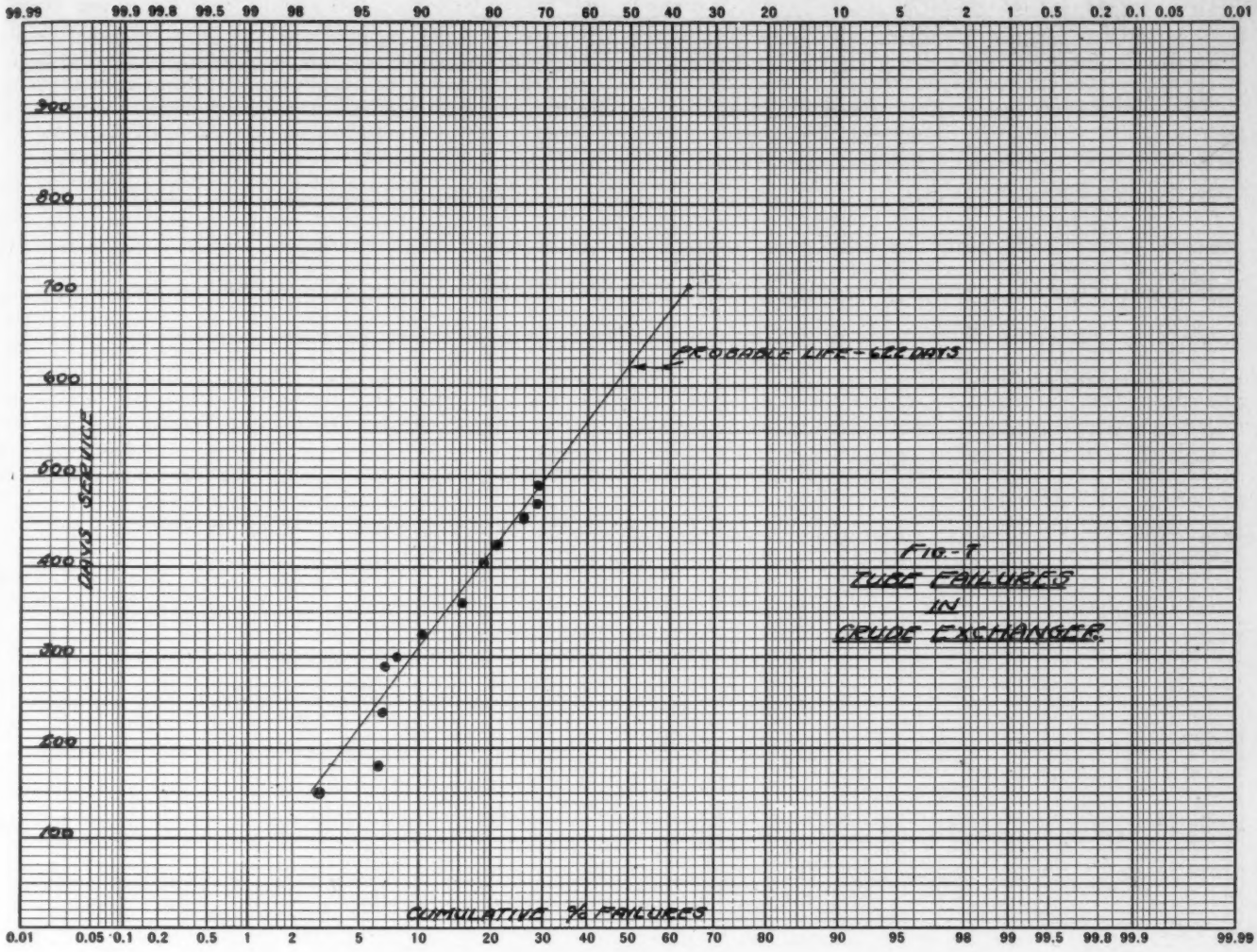

FIGURE 7

tions follows the normal curve. He attributed the variation in probable life of the pipe to different corrosivity of the soil in which the pipe was buried.

In connection with these studies on corrosion rates and probable life of materials from a corrosion standpoint several interesting features are apparent. First, the intersection of the straight line drawn through the points with the 50 percent line on the paper indicates the most probable life of the material or set of samples under observation. Next that it is possible to find the time at which the greatest number of failures will occur by extrapolating the straight line, and last, that the number of failures occurring at this maximum can be calculated. Determination of the most probable life is self evident after the data has been plotted, and Passano and Hayes have devoted considerable space in their dissertation to a description of how the last two items can be found. A brief review of their method follows.

In the equation

$$X \qquad y = ke^{-h^2(a-x)^2}$$

where y = number of failures and
x = time at which the failures occur

which is an expression of the probability curve or the curve of normal error, a maximum results at the point where the largest number of failures occur. In order to find this point it is necessary to set the first derivative of the function equal to zero.

$$XI \qquad dy = 2h^2ke^{-h^2(a-x)^2}(a-x)\,dx = O$$

Therefore the maximum on the curve is at the point where $x = a$, which means that "a" is the time at which the largest number of failures occur. Returning to equation II and setting $x = a$ it is found that,

$$y = ke^{o} = k$$

which establishes that "k" is the number of failures which occur at the maximum "a."

In the article quoted[5], it should be stated that there was a close agreement between the number of failures found and the number that would be predicted by probability considerations. Their data were supplied by various investigators and therefore would contain a human element which might be expected to cause a certain amount of disparity among the data. On the other hand the experiments were performed under controlled conditions which would be difficult to duplicate in refinery equipment in continuous operation.

In the data plotted on Figures 7, 8, and 9, there was no chance to secure such controlled conditions because the observations were made on commercial cracking units and on a crude-topping unit, all of which were in commercial operation. Therefore it is to be expected that some variation from a perfect agreement of data should occur.

Figure 7 shows the results of tabulating the number of tube failures occuring in a crude-to-gasoline exchanger during approximately 18 months operation. A great deal of trouble was experienced from these tube failures, since each time a bad failure occurred it was necessary to shut down the crude unit on account of crude leaking into the gasoline stream. Collection of the data shown in Figure 7 was started

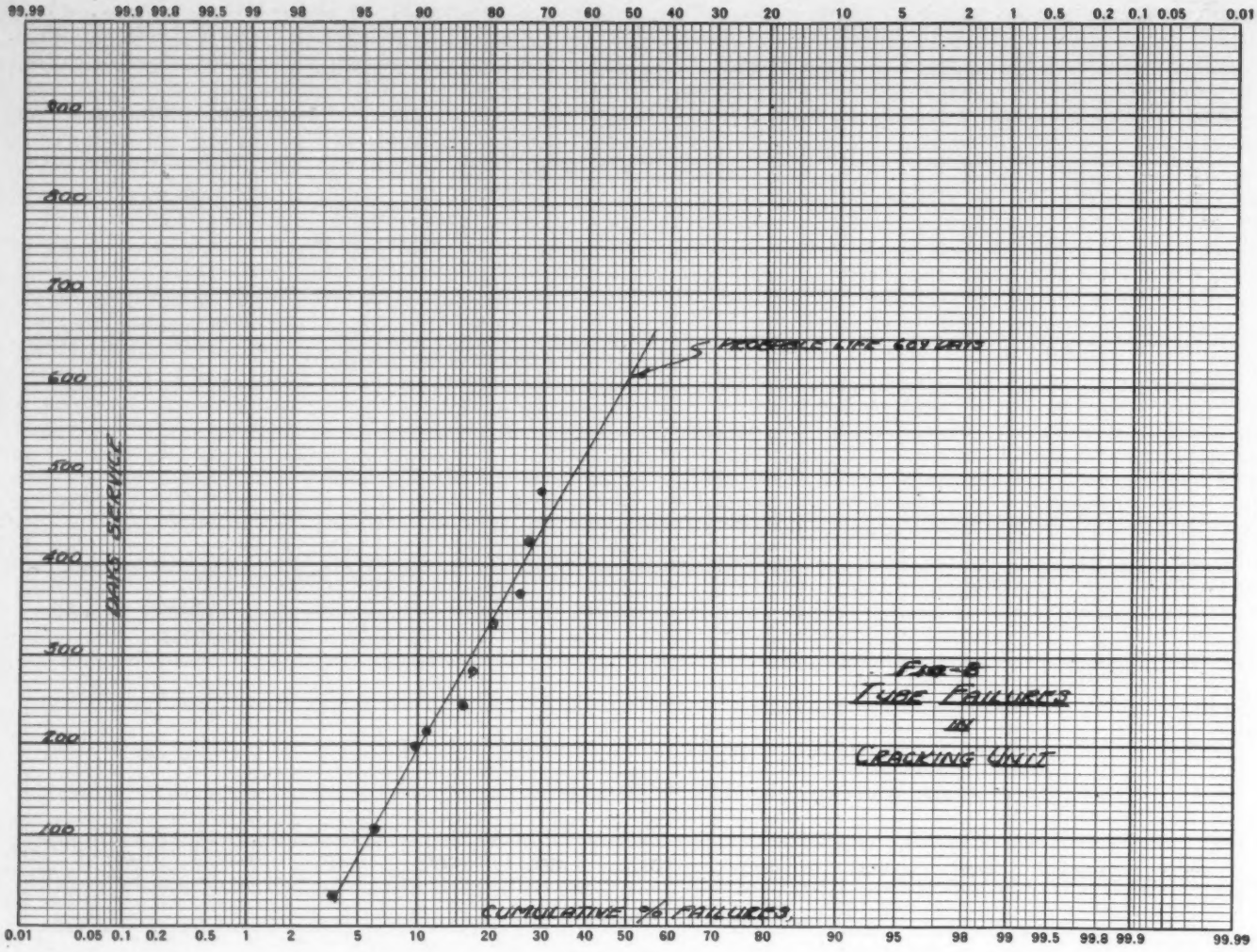

FIGURE 8

after some months of trouble had been experienced and it was decided to investigate the savings to be accomplished by replacing the admiralty bundle of the exchangers with some more resistant material. Because of this elapsed time before starting to collect the data, it is doubtful if the number of failures shown on the figure is extremely accurate, because in some cases doubtful tubes were removed which may not have actually failed. As a compensating error, however, the earliest method used for testing the bundles was not particularly satisfactory and some small leaks undoubtedly were overlooked until the next inspection period, when the leaks had enlarged to where they could be easily detected.

From Figure 7 it is seen that although about 30 percent of the tubes had failed at the end of approximately 500 days, yet the "probable life" of the tubes would be 622 days. This large percentage of failures at the end of 500 days shows an unfavorable distribution of failures. In other words, if tube failures must occur in operation it would be preferable to have the failures occur in a more concentrated manner so that shutdowns would not occur so often. This would be the case if the points on Figure 7 fell on a steeper line. The slope of the line therefore indicates the distribution of failures around the most probable life, and is easy to understand that a steep slope is to be desired in any material to be used. This slope is measured by the "h" exponent in Equation II. It can be evaluated in several ways, Passano and Hayes[5] probably describing the easiest method.

The value of plotting corrosion data in this manner is two-fold. First the probable life of the material under test can be closely estimated by extrapolation after only enough time has elapsed to give a few points for plotting. This allows replacements to be ordered or changes to be made without waiting a long time. The second valuable feature of the method is that the slope of the line so plotted furnishes an index as to the suitability of the material for the intended service.

Figures 8 and 9 show the results of plotting the cumulative percentage of radiant tube failures against length of service of cracking still tubes. Both the units for which the data is plotted were black-oil cracking units. Tubes in such service are more subject to failure from local overheating than are tubes used in clean circulation service, and this, considered along with other variables such as imperfect cleaning, makes it surprising that the data for the two units agree as well as Figures 8 and 9 indicate. It is reasonable to suppose that all factors such as erosion, corrosion, uneven cleaning, local overheating, etc., combine into one common rate of deterioration so that failures tend to conform to the normal distribution curve. In selecting the data for these two figures, the records for tube replacements on the two units were studied, and insofar as it was possible to

do so, all irrelevant failures were deleted from the tabulation.

Today, when the art of cracking has progressed an appreciable distance along the road to becoming an exact science, tube failures are no longer the bugbear they once were. With clean circulation, operators becoming more and more cognizant of the fine points of their job, and furnace design comparatively well founded, it is possible to operate a unit for years without a tube failure. There still remains the problems of erosion and corrosion to be dealt with, and it is in this field that statistical treatment should be useful.

In any one of a dozen large companies there are enough similar cracking units, crude units, treating plants, or even single items such as towers or tanks, where a statistical treatment could be used to affect large savings and to determine the type of equipment to purchase. For example, in a cracking unit there is often a comparatively low temperature zone where corrosion of tubes and headers is rapid. This is in the vaporization zone of the furnace where a change of state from liquid to vapor occurs. This section of the tubes usually lies in one of the convection banks and the problem is primarily one of corrosion rather than erosion at this point. As has been shown on Figures 8 and 9, data from even a single unit arranges itself in an intelligible manner when properly treated, and if all the similar convection banks of all the similar units of one of our large companies were to be studied and analyzed it amounts to almost a certainty that a very accurate picture would be obtained regarding the life of tubes in such service, the annual cost of corrosion of these tubes, and the savings or losses to be effected by replacing these tubes with special resistant alloys.

In studying refinery problems it appears to be not a question as to whether a statistical treatment will work; but whether the data is available so that past performance can be investigated. If such data is not available then it seems to be reasonable to state that the probability treatment not only offers a very satisfactory method of analyzing future or contemporary data; but also that this method will give a quicker insight into the utility of a material than any other sound method, and that predictions can be made as to the usefulness of a material after comparatively short trial periods.

ACKNOWLEDGEMENT

The writer wishes to acknowledge the valuable assistance rendered by Mr. G. S. Dunham, and by Mr. H. L. Bedell in collecting some of the material used herein. Mr. Dunham also devised a very sensitive pressure regulator which was used in performing the distillation of the oil shown in Table I.

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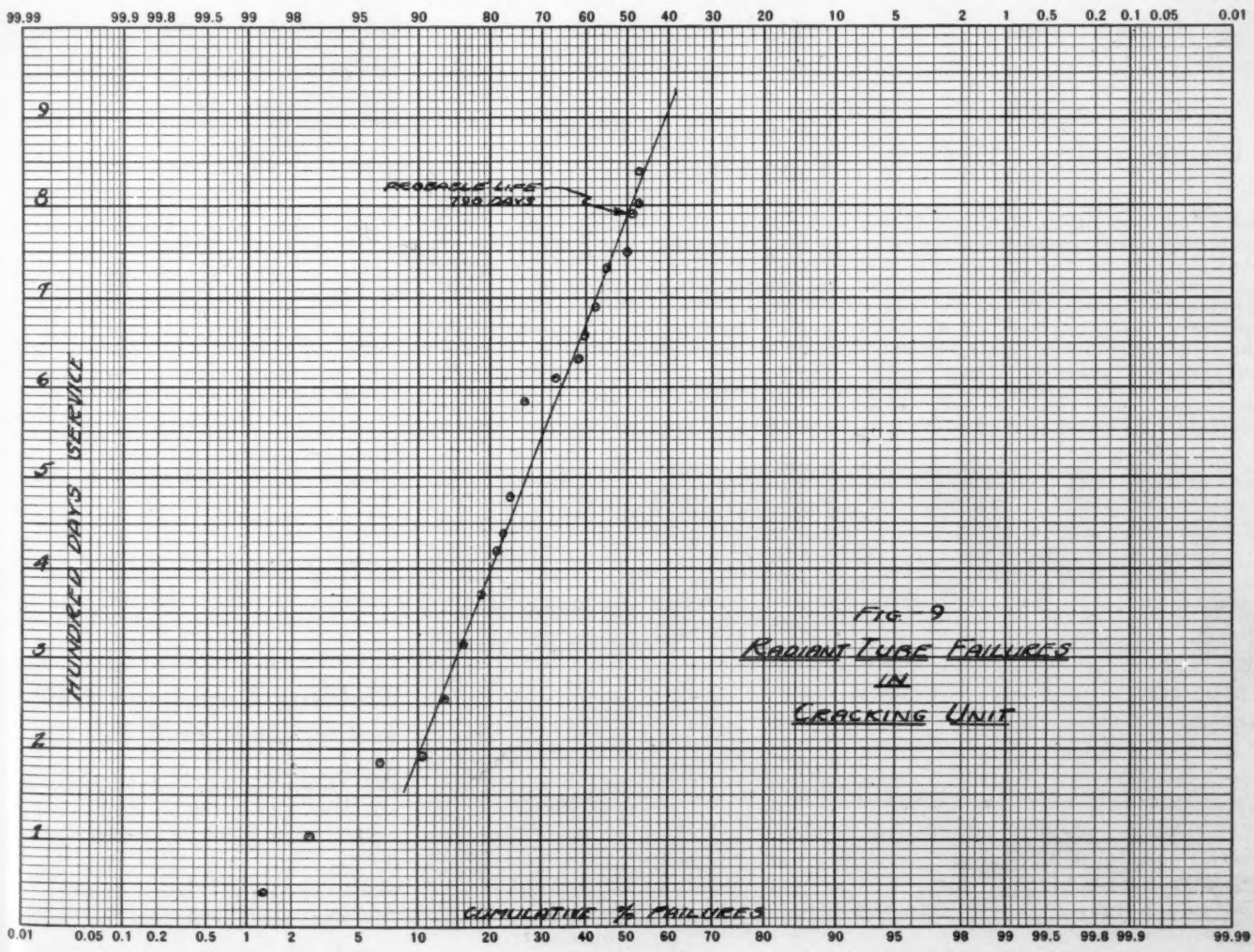
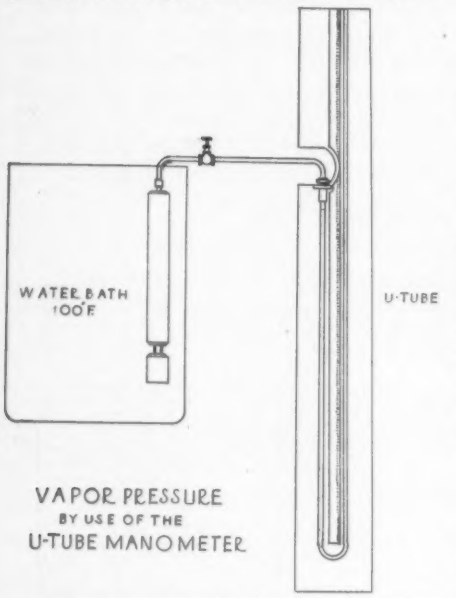


FIGURE 9

IDEAS to help plant efficiency...

Vapor Pressure With the U-Tube Manometer

THE U-tube manometer can be applied satisfactorily to the determination of vapor pressures of gasolines. The sketch shows the details of the complete apparatus, minus the usual gauge, connected to a U-tube manometer. The procedure is the same as usual in taking vapor pressures. The valve shown is closed and the line to the manometer not connected at the beginning of the test. When the vapor pressure reading is ready to be taken the coupling shown is firmly connected and the valve opened. The difference in the mercury columns, multiplied by the usual factor gives the true vapor pressure. The coupling is securely fastened to the back board so that there is no danger of breaking the glass tube while connections are being made. The coupling is placed on the tube near the normal position of the mercury column so that vapors or condensate can be swabbed out after each test. The connecting line and the valve are insulated to eliminate error.



VAPOR PRESSURE
BY USE OF THE
U-TUBE MANOMETER

M. E. WOOLDRIDGE,
Ponca City, Oklahoma.

Heating and Cooling Baths

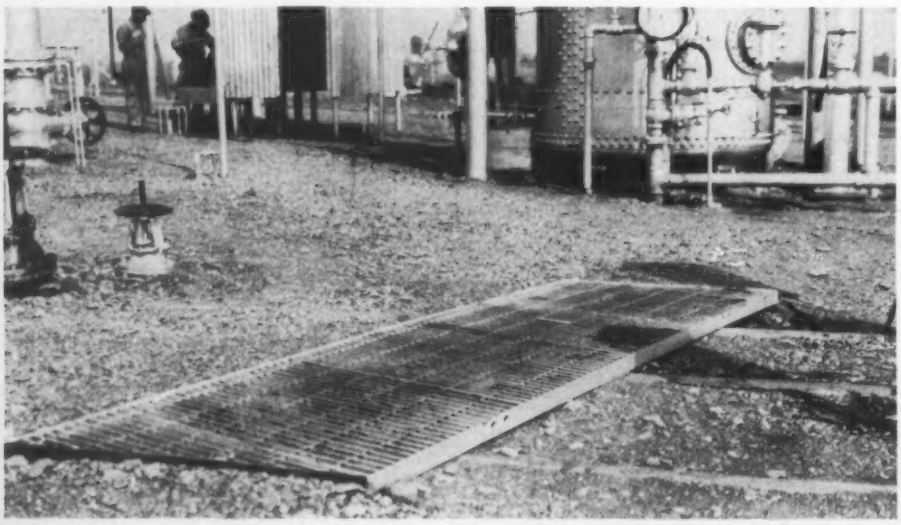
THE ASTM procedure requires preheating and cooling the pour test samples under specific conditions. A serological water bath, thermostatically controlled (available from any good laboratory supply house) makes an excellent heating bath requiring almost no attention once it is properly set. The shell of a discarded 4-tube viscosimeter will serve for a cooling bath. Racks for the two baths may be made from brass screen and wire. It will generally be found cheaper to buy an electrically heated bath than to attempt to construct one out of purchased parts.

G. F. F.

Grating Over Plant Pipe Lines

TO prevent accidents to employees, Carter Oil Company has placed walks above plant pipe lines which are not completely buried. Men are exposed to hazards when stepping upon rounded pipe surfaces due to slippage, so angle iron frames are made in the welding shop which conform to the angle of the plant walks and the pipe lines which they cross.

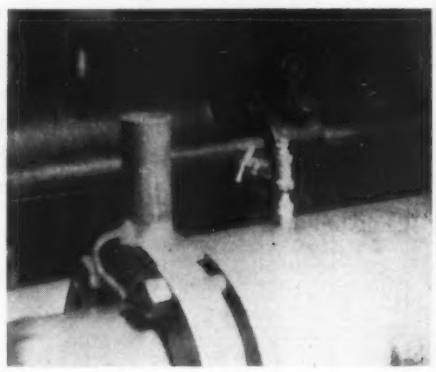
The frames are welded as a unit, and the grating used to fill the sections is removable, but fits tightly so no movement occurs when one steps upon the walk above the lines. Ideas of this nature originate largely with the employees because of the "Cash Your Ideas" club sponsored by the company, and which sets the men to thinking how safety can be promoted, as well as new ideas which may speed up and lessen the cost of gasoline production.



Carter Oil Company's walk over pipe lines in Fitts gasoline plant.

Piston Lubricator

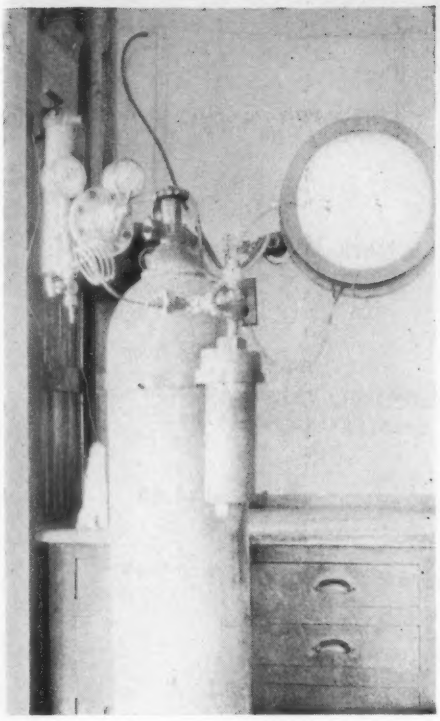
ATLAS OIL CORPORATION'S employees designed a simple apparatus for lubricating outside piston-packed pump plungers that were handling extremely volatile liquids. Light tubing was used for lubrication containers, cut about four inches in length, with an oil-tight bottom welded to each unit. Quarter-inch copper tubing was brazed to one side at the lower end after a small orifice was drilled in the tube. The orifices are of various sizes, depending upon the amount of oil desired for lubrication under practically constant head and temperature. The lubricators were spot welded to the plunger packing gland, with the copper tubing bent so that the drops of oil will fall where most needed. A small pad of cotton was placed in the bottom of each lubricator before filling to prevent foreign matter from clogging the orifice. Castor oil is the material used for lubrication, as it is not readily dissolved in a propane-butane mixture.



Outside piston pump plunger lubricator.

Welding Regulator for Induction Period Bomb

MOST potential gum or induction period oxygen bombs employ initial oxygen pressures of 100 pounds per square inch. Since it is hazardous to admit the oxygen directly from the cylinder into the bomb some sort of regulating device makes its need felt. An ordinary oxygen welding regulator that will release a maximum of 105 pounds per square inch, or more, is easily adaptable. The hose adapter is



Welding regulator.

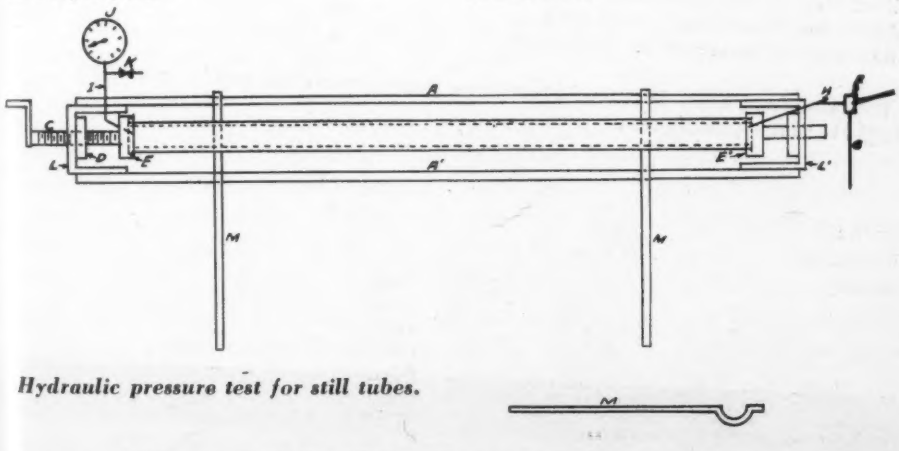
taken out of the body of the regulator and ¼- or ⅛-inch brass fittings used to connect the oxygen supply to the bomb. A safety valve set to release at 110 pounds per square inch may also be included on the low pressure side of the regulator.

HAROLD BOTTOMLEY,
Arkansas City, Kansas.

Test for Still Tubes

THE reconditioned tube is placed between the flanges E and E′ and supported in place by M.M′. Flange E has a swivel joint attachment to screw C by which it is adjustable. Flange E′ is stationary. The flanges have an asbestos packing. Bars MM′ are supported by I beams A,A′. A ¼-inch nipple I is attached to flange E. To this nipple is attached a 2000 pound hydraulic gauge J with ¼-inch valve K as a bleeder. When tube is in place and flanges are tight, water is entered through hose or pipe connection G to hydraulic hand pump F and enter tube through ¼-inch nipple H. I beams A,A′ are connected by steel braces L,L′. D is a boss built up to give thread material for screw.

J. O. GRIFFIN,
Shreveport, La.



Hydraulic pressure test for still tubes.

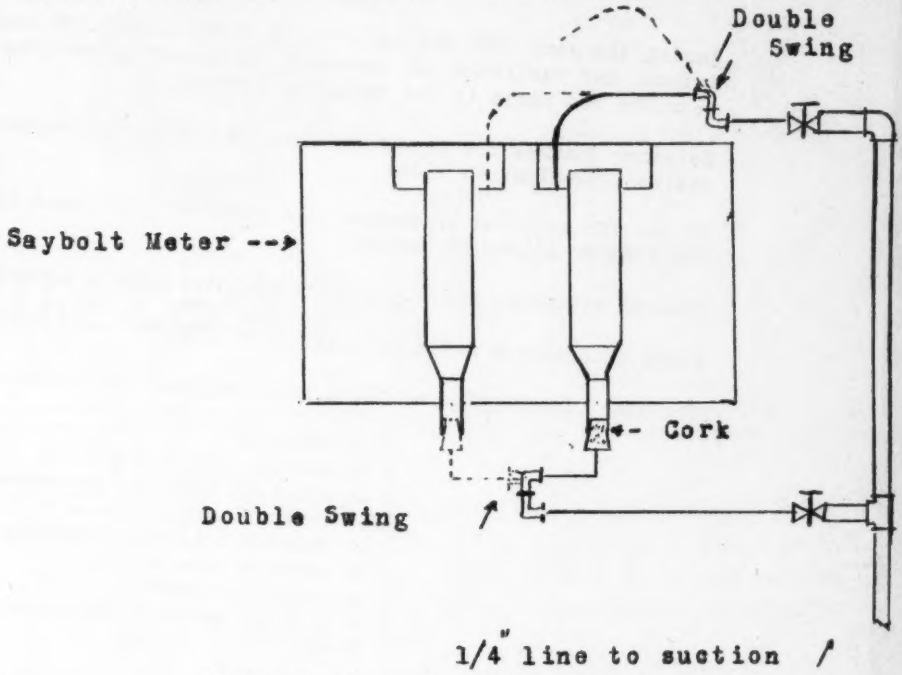
Suction Attachments for Viscosimeters

THE old method for removing excess oil from the overflow gallery of the Saybolt meter required the use of a glass pipette with a large suction bulb attached. Oil remaining in the tip of the tube was plunged out. This procedure is not only sloppy and inefficient but the pipette is subject to breakage and the bulb to rotting. "Plunging" tends to score the meter tube, introduces foreign matter into the tip and is not sufficiently effective for accurate work.

A superior device is that illustrated. It is simple and inexpensive and may be installed readily in any laboratory where power suction is available. Ordinary 3/16-inch copper tubing and fittings are used in connecting to the ¼-inch suction line. A suitable trap is used to prevent carry-over of oil to the pump.

Proper swivel and swing joints are provided so that suction may be applied to either tube of a two-tube meter. Duplicate set-ups will service a four-tube meter. No rubber tubing is employed and once installed the attachments are permanent.

GEORGE F. FITZGERALD,
Olean, N. Y.



Suction attachment for Saybolt viscosimeters.

Pertinent Packing Pointers

THE following suggestions and warnings, based on the many years of practical experience of a prominent packing manufacturer, will be found valuable in the installation of packings. To follow them may mean freedom from trouble that would occur when even the best packing is improperly installed.

1—Never fail to make clear what the packing is to pack. In other words, with what will the packing make contact? If it is to come in contact with a highly solvent oil or other liquid that fact may be exceedingly important.

2—Never guess at a size, diameter, width or height, when ordering packing. Many failures result from small errors in dimensions.

3—Never allow too little or too much clearance between follower plate and inside cup wall, or any metal parts behind any upright leather wall; 1/16 to 3/32-inch on each side, depending on size of packing, is recommended.

4—Never doctor packing lips with a pocket knife or file, or batter lip in installing. A rounded lip destroys the seal. Packings can be softened by soaking in warm water if necessary.

5—Never apply cup packings with flange too high for clearance at the head of the cylinder. Keep systems clean, so sediment will not collect in cylinders and wear the packing.

6—Never apply cup packings to end of plunger which is badly worn; pressure will force the packing down into clearance between plunger and cylinder. Leather washers cut from old cup packings can be made to reinforce the heel of cups on worn plungers.

7—Never apply "U" packings where plungers are worn without reinforcing under heel with leather cushion rings.

8—Never look for long service on scored plungers or in scored cylinders; resurface or reline such equipment to proper dimensions.

W. F. SCHAPHORST.
Newark, New Jersey.

OFFICE MEMORANDUM

FROM: GEO. H. REID, Editor DATE January 10 1937

TO: RAY L. DUDLEY, Publisher, The REFINER

During the year 1936 The REFINER AND NATURAL GASOLINE MANUFACTURER, Volume 15, 12 issues, has published 155 technical, engineering and plant descriptive articles, totaling 584 pages in the technical section.

No other journal has approached The REFINER in the number of articles published on refinery problems in 1936.

Of the 155 articles presented this year, 29 (18%) have been of the highly important ENGINEERING ECONOMICS series.

General technical and engineering articles have totaled 95 (62%).

Plant description articles totaled 31 (20%).

The plant description articles have included the following:

5 on cracking
7 on general refineries
2 on chemical treating processes
1 on drum cleaning
2 on solvent refining processes
1 on asphalt manufacture
18 on refining division
13 on natural gasoline manufacture
31 Total

Location of plants covered by "Plant Description Articles": California, Oklahoma, Pennsylvania, Kansas, Texas, Arkansas and Louisiana.

Another type of breakdown on the material published during the past year follows:

Articles dealing with petroleum refining problems - 118 (76%)
Articles dealing with natural gasoline manufacture - 37 (24%)

Out of the group of 95 engineering and technical articles, there have been 27 convention papers used. This is 17% of the total of 155 articles of all types. The papers were from the following sources:

American Institute Chemical Engineers	- 1
American Society for Testing Materials	- 2
Western Petroleum Refiners Association	- 6
Natural Gasoline Association of America	- 3
National Petroleum Association	- 1
American Petroleum Institute	- 13
Society of Automotive Engineers	- 1

During the year 2 translations from German literature were presented and 6 articles by foreign technologists were published.

GHR:LM

CC - Mr. Burns
Mr. Robinson
Mr. Ridley